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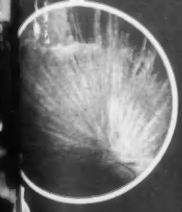

GALLIUM ARSENIDE TUNNELS

	Page
	1
On the Back Cover	3
Chemical Defenses	10
Molecular Weight Apparatus: Apparatus Article	17
Chemistry Quiz	18
Proudly Presented	19
Chemical Companies: Dow	24
For the Home Lab: Nitric Acid	30
New Chemical Patents	32
Thermal Expansion of Liquids: STS Project Report	34
A New Journal	40
Silica Gel	42
Radioisotopes Experiments	45
Book Condensations	48
Chemistry Comments	Inside Back Cover

Editorial:
Chemistry and Archeology
Inside Front Cover

50¢

Thirty-fourth Year

A SCIENCE SERVICE PUBLICATION

Chemistry and Archeology

➤ THE SCIENTIFIC STUDY of the remains of past human life and activities is called archeology. This involves the investigation of the changes undergone by antiquities in the earth and in the air, the nature of archeological deposits, the substances used in ancient technological processes and the processes themselves.

The application of chemical testing methods to the materials of archeology produces large amounts of useful information. Chemical methods of preservation are applied by archeologists as well as chemical methods of cleaning and restoration. The first paper on archeological chemistry was published in England in 1796. The interest in archeological chemistry has developed so much since that date until a special symposium on the subject was held at the 117th meeting of the American Chemical Society in 1950.

Chemical analysis of metallic objects furnishes information concerning the state of development of metallurgy for a given period as well as information concerning the sources of ores. Spectrographic analysis is particularly useful in the study of metal, glass and pottery. The size of the sample required is very small so that very little destruction is involved.

The 1960 Nobel Prize in Chemistry went to Dr. Willard Libby for the development of a method of dating objects of plant or animal origin. Dr. Libby found that the carbon-14 content of these materials decreases with the age of the object. This method permits the accurate dating of sites up to an age of 30,000 years. He has moved the dating process in archeology from guesswork to scientific precision.

The identification of dyes and pigments used by pre-historic societies have been identified by the use of the spectroscope. This method is so efficient that not only can the mineral pigments used in pottery be identified but even the individual organic dyes can be recognized. This method even permits the identification of the mordants used in the dyeing process.

The extremely interesting science of archeology finds the techniques and principles of chemistry invaluable. The chemist is able to help the archeologist unravel some of the many riddles of the ages.

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Gallium Arsenide Tunnels

Newest entry in the field of wonder electronic devices for computers and other uses is a bit of apparatus known as a tunnel diode. It competes with the transistor, and promises to outdo it for space communications.

by JOHN COLLINS

➤ THE YOUNGEST wonder of modern electronics is a minute apparatus known as a tunnel diode. It competes with the transistor and promises to out-perform transistors for space communications, fast computers and radar receivers.

The tunnel diode was discovered by Dr. Leo Esaki, a young Japanese physicist from the University of Tokyo. The device is sometimes called the "Esaki" diode in his honor.

Tunnel diodes belong to a group of products called "semiconductors" because they are made of materials — usually either germanium or silicon — that conduct electricity better than insulators but not as well as metals.

Gallium Arsenide

Many semiconductor materials are being investigated to find the best one for the job. Both germanium and silicon tunnel diodes have been made but a new compound, gallium arsenide, appears to be even better.

A tunnel diode does not have a tunnel — at least, no visible tunnel. The name is derived from the remarkable way in which electrons, under proper conditions, pass through the potential barrier existing between the positive and negative sides of a semiconductor diode, as if through a tunnel.

The tunnel diode's value lies in the small range where an increasing voltage results in a decreasing current. This occurs because the resistance becomes smaller with increased voltage. The effect is called "negative" resistance.

Negative Resistance

Long before tunnel diodes were conceived, theoretical physicists showed that negative resistance elements can be used as amplifiers or oscillators, just as radio tubes. Since no suitable negative resistance devices were available, however, little progress was made until tunnel diodes became available.

Tunnel diodes are superior to transistors in many ways. Even in their young stage, they operate well above 1,500 megacycles and have predicted working frequencies of about 10,000 megacycles. A gallium arsenide tunnel diode has been made that works at frequencies above 4,000 megacycles. Few transistors can operate at more than about 100 megacycles.

Tunnel diodes can be used at temperatures up to 650 degrees Fahrenheit, compared to 400 degrees for transistors.

Transistors are quite sensitive to nuclear radiation. Tunnel diodes can withstand about 1,000 times as much without damage. Tunnel diodes can

also be made smaller than transistors, but this is a minor advantage in view of the tiny size of many transistors.

The ability of tunnel diodes to withstand radiation will be important in space communications where transistors are subject to damage from cosmic rays and the intense particle bombardments that accompany sunspot activity. This factor will also lead to their use in control circuits for nuclear reactors.

Like other semiconductor devices, tunnel diodes have a low noise level. Because of this and their ability to amplify ultrahigh frequency signals, they are expected to increase further the sensitivity of radar receivers.

Rapid Switching

The importance of tunnel diodes for computers results from the fact that they can be switched rapidly from a high resistance to a low resistance by a small voltage. Switching is like turning a switch on and off; it provides the on-off operation needed for digital computers. Because of the phenomenal speed of the tunnel diode, computers faster than those available today should result.

Several American manufacturers are now marketing tunnel diodes and some are being imported from Japan. Tunnel diodes are not yet used in large quantities, although prototype computers and other experimental equipment containing them have been built.

The present small output is not unexpected. Transistors were invented in 1948 but did not get into effective production until about 1953. The tunnel diode was invented in 1958. It promises to provide an answer to many nagging problems. The next few years should see a boom in both its production and application.

The tunnel diode is a distant cousin of the ancient galena crystal and cat's whisker wire used as a detector in the early days of radio. The crystal was clamped or soldered in a receptacle and the wire was moved about on it to find a "sensitive" spot for good reception.

Silicon Diode

World War II and the invention of radar brought a change. The noise generated by tubes in the front end of a radar receiver was found to mask the incoming radar signals and limit the sensitivity of the equipment.

The problem was solved by reviving the crystal diode as a frequency converter and eliminating the tube in that stage. The diode used was a silicon unit sealed in an especially designed case. Millions were produced during the war years.

Semiconductor research continued after the war. One of the most important discoveries was the "p"-"n" junction, which has virtually eliminated the cat's whisker wire in semiconductors.

A "p"-"n" junction is the point of union between "n"-type, or negative type, and "p"-type, or positive type, semiconductor materials. No free charges exist at the junction and it constitutes a barrier to current flow. Electrons in an ordinary junction diode are able to flow from the "n" to the "p" region when their energy is raised enough by an external voltage to surmount the barrier.

Conductivity is increased by "doping" the semiconductor material with traces of other elements to provide free charges. Some elements, such as

boron, aluminum, gallium and indium, provide free electrons (negative charges) and the material then becomes "n"-type. Other elements, such as phosphorus, arsenic and antimony, result in an excess of positive charges, called "holes," and the material is then designated "p"-type.

"P"-"n" junctions are the nucleus of tunnel diodes as well as most crystal diodes and transistors.

However, another path exists. A principle in quantum mechanics holds that an electron approaching a potential barrier has a small but finite probability of disappearing and instantly reappearing on the far side of the barrier. The transfer occurs at the speed of light and is called the tunnel effect. With ordinary junction diodes, the number of free electrons is small and tunneling occurs so rarely as to go unnoticed.

Dr. Esaki's contribution was studying the tunnel effect in materials doped to saturation so as to multiply the number of free electrons and thereby increase the probability of tunneling. Under that condition, and with no external voltage, electrons on both sides of the potential barrier are at a common energy level and tunnel from either side with equal ease. They thus tend to cancel each other and there is no net current flow. However, if a very small voltage is applied to raise the energy level of the electrons in the "n" region, the tunneling from that side becomes greater and a current flow results.

Over a small range, the current increases when the voltage is raised, as in an ordinary electrical circuit. As the voltage is further increased, however, the electrons in the "n" region reach an energy level that puts them opposite the so-called "forbidden energy gap" of the "p" region.

The forbidden energy gap is something like an elevator between floors. Passengers can get off at one level or the next, but cannot get off in between.

Electrons cannot tunnel from the "n" region into the forbidden gap, so the current begins to decrease. The decline continues until the energy of the electrons becomes great enough to surmount the potential barrier, at a level above the forbidden gap. When that happens, they pass over the barrier (not through it) in the normal manner, and the tunnel effect is at an end.

On the Back Cover

➤ THE BACK COVER *shows modern chemical engineering equipment used in the plastics industry.*

Focal point of an inspection tour of The Glidden Company's main paint plant here recently by Case Institute seniors in chemical engineering was the firm's new Universal Reactor, a unit which produces a wide range of modern resins. Viewing the unit were (left to right) Dr. Robert J. Adler, associate professor of chemical engineering at Case; students Skip Kress and James Prutton, and Charles A. Jonic, a plant engineer who is explaining operations of the unit. The Case inspection tour was sponsored as part of the program to speed up the flow of technical information between classroom and industry.

Age of Universe Questioned

➤ THE UNIVERSE may be a million billion years old, not just 12 or so billion years old, an astronomer has reported.

Dr. Fritz Zwicky of Mt. Wilson and Palomar Observatories told the American Astronomical Society meeting that a million billion years was the least time required for the formation of galaxies, the vast stellar systems of which the earth's Milky Way is only one of billions.

Dr. Zwicky bases his estimate for the age of the universe on the fact that atomic nuclei, the building blocks of matter, react with one another and can radiate. Because atoms react, characteristic groupings of matter are built up. Among these groupings, the stars, of which the sun is only one of millions within the Milky Way, are the most prominent.

Stars cannot grow beyond a certain size because of destructive effects of the energies released when atomic nuclei react, Dr. Zwicky reported. The next higher units of matter are those of the centers of galaxies.

Galactic centers, also, cannot build up beyond a certain size because of certain destructive effects. If they could continue building, they would grow in size indefinitely.

Since there is a limiting size, however, Dr. Zwicky suggests that the cores of galaxies represent a new unit of cosmic matter, the true character of which has not yet been recognized. This character is, however, "just as distinctive as the character of stars," Dr. Zwicky reported.

He described galaxies as follows:

Around a dense and very luminous nucleus, a large disk of much lower brightness is found. The nucleus is some tens of light years in diameter, a light year being the distance light travels in a year at 186,000 miles a second, or some six million million miles.

The disk is surrounded first by a scattered "suburban" population of stars, gas and dust clouds that may be lined up along a number of more or less well defined spiral arms. Around this surburban population there may be a faint halo of stars and dark gases. Finally there are intergalactic formations hovering around the galaxy.

The disk, suburban populations, halos and intergalactic formations have dimensions of a few to many thousands of light years, always much larger than the nuclei of galaxies.

Zero Energy Reactor Planned

➤ THE United Kingdom Atomic Energy Authority will build a zero energy fast reactor at Winfrith. The reactor is called ZEBRA (Zero Energy Breeder Reactor Assembly), and will permit the study of the neutron physics of a wide variety of fuel assemblies, containing uranium and plutonium, which have been built up by loading fuel elements into a steel matrix. The zero energy reactor will begin operation during 1962.

Primary Clue Found

➤ THE SHORTEST lifetime of an elementary particle, only a quarter of a millionth of a billionth of a second, gives a primary clue to the structure of matter.

This new figure, which links the nuclear mesons directly with the electromagnetic field for the first time, was reported to the tenth annual International Conference of High Energy Physics at the University of Rochester, N. Y., by Dr. A. V. Tollestrup of the California Institute of Technology.

The fleeting lifetime was found by Dr. Tollestrup and his co-workers and by Dr. R. G. Glasser and his group at the Naval Research Laboratory in Washington. The scientists examined photographic emulsions to find the tracks necessary to measure the lifetime of the neutral pi-meson. The emulsions were exposed to beams of K-particles in the giant six-billion-electron-volt atom smasher at the University of California at Berkeley.

Disintegrating atoms leave their tracks in the emulsions, and scientists glean much of their information about nuclear structure by studying these tracks.

The lifetime of nuclear particles is one of their principle properties.

Pi-mesons as a separate class of nuclear particles were first suggested in 1948, and the first examples were spotted experimentally within two weeks. Besides a positive and negative pi-meson, scientists have known for about ten years of the neutral pi-meson and have been trying to pin down its lifetime.

The new measurement gives theoretical physicists a new universal constant and now they must figure out why it exists or relate it to another constant. When the neutral pi-meson breaks up or decays, two photons of light are produced. These photons, or gamma rays, are purely electromagnetic in character.

Thus the new measurement links mesons and the electromagnetic field for the first time.

The neutral pi-meson is the only one of the 30 particles now known to break up in this fashion. Its lifetime is also shorter by a factor of a million than any of the other known particles.

The possible existence of another new particle called "D" for Dubna where it was first spotted by the Russians was also debated. Only four possible examples have so far been found, so its status as a particle is rather shaky.

Furnace Hotter Than Sun

➤ HEAT NEARLY three times that of the sun's surface can be produced by a furnace at the Naval Ordnance Laboratory, White Oak, Md. The electric arc furnace is being tested for use in the study of new materials for rockets.

Its electric arc can generate temperatures up to 27,000 degrees Fahrenheit.

Unique Chamber for Helium Recovery

➤ ONE OF THE newest aids to space research is a hypersonic shock tunnel that shoots a "bullet" of air through a test chamber at 16 times the speed of sound. The charge to fire the cannon-like device is helium gas under high pressure. And one of the features that make this research tool practical is a double-walled air-supported structure of tough nylon fabric coated with "Hypalon" synthetic rubber.

The hypersonic shock tunnel was developed by Cornell Aeronautical Laboratory, Inc., in Buffalo, N. Y. Its purpose is testing models of missiles and aircraft to gain precise aerodynamic measurements of performance. An outstanding feature is production of uniform hypersonic airflow for 15 milliseconds, some eight times longer than possible with any previous shock tunnel.

The shock tube, which generates high pressure, high temperature air for the tunnels, is a 90-foot metal tube divided by diaphragms into high and low pressure sections. The low pressure section is filled with air. Helium is pumped into the high pressure section until it reaches a planned pressure which ruptures the diaphragm. As the helium rushes into the adjacent section, it produces a shock wave, compressing the air "bullet" and raising its temperature rapidly.

The hot, pressurized air flows through a nozzle and is accelerated into the test chamber, where it passes the test model at temperatures as high as 7,500 degrees Fahrenheit at velocities up to Mach 16 — or 16 times the speed of sound. During the fifteen-thousandths second testing period, special instruments developed by the laboratory measure the forces, pressures, and temperatures acting on the model.

Once through the test chamber, the gas passes into a receiving chamber maintained as an almost complete vacuum. Here the gas can expand until its pressure is reduced to four times that of the atmosphere. This also reduces its temperature.

One problem in developing the installation was an effective system for recovering the helium, a critical defense material. Various solutions were discarded as too costly or too cumbersome. Finally a special all-fabric air-supported structure made of nylon coated with "Hypalon" synthetic rubber was selected.

The helium passes from the receiving chamber into the 5,000-cubic-foot fabric structure, from which it can be pumped easily into storage tanks. There it is exposed to liquid nitrogen to freeze out contaminating air, leaving the helium ready to be pumped into the cannon for another test shot.

Choice of materials for the air structure was critical. Because it would be outside, resistance to weathering, aging, sunlight, and ozone was paramount. Considerable strength and lasting flexibility were necessary to withstand changing stresses as gas entered and left. Finally, impermeability to gases was a prerequisite, to avoid loss of helium.

The material chosen was a nylon-base fabric coated on both sides with "Hypalon."

The original thought of using a single-walled structure was discarded because of the instability of an untensioned, partially inflated envelope. Instead the present double, concentric-walled structure was proposed. The inner chamber is inflated with air as required to keep the outer wall tensioned and stable at all times. The helium enters the outer chamber between the two walls, depressing the inner wall and exhausting air as required to provide the necessary helium storage volume. Both walls are anchored to an elliptical concrete base measuring 20 x 40 feet.

"Hypalon" synthetic rubber was introduced commercially by the Du Pont Company in 1951. It is completely ozone proof, and has outstanding resistance to oxidizing chemicals, heat, abrasion, sunlight, and weathering.

In addition, it can be lastingly colored, adheres well to fabrics or metals, and resists damage by mold or mildew. It is useful over a temperature range from minus 80 to plus 350 degrees Fahrenheit, and has a tensile strength greater than 3,000 pounds per square inch.

Nuclear Energy to Produce Fresh Water

➤ FRESH WATER from the sea soon may be available at low cost by means of nuclear energy, as a result of a joint effort of the Saline Water Division of the Department of the Interior and the Atomic Energy Commission.

The signed contract for the nuclear portion of this program is $4,500,000. Five years ago, estimates for the type of nuclear reactor necessary for desalting water ranged as high as $4 to $5 billion.

Experts predict that the use of nuclear power for the desalination program will make available fresh water from the ocean at no more than the present cost of drinking water in the 400 largest cities in the United States. The site chosen tentatively for the nuclear desalination plant is San Diego, Calif.

Chemical Nature of Cell Division

➤ A PROTEIN or two proteins with many hydrogen linkages form the strands of the spindle which is an essential mechanism in the division of a living cell, according to a New York University scientist.

Dr. Paul R. Gross, co-chairman of the second conference on cell division held by The New York Academy of Sciences, said that treating rapidly dividing eggs from sea urchins and other marine organisms causes the process to come to a halt.

By various tests Dr. Gross was able to determine that the deuterium oxide (water formed from the hydrogen isotope, deuterium) did not interfere with the cells' duplication of chromosomes nor does he believe there is interference with the cells' accumulation of the energy supply needed for division.

The scientist said he is convinced that D_2O upsets the formation of the strands which form the spindle. These strands act to pull the separated

chromosomes to the poles or asters which will be the nuclei of the two daughter cells into which the original unit is dividing.

Because it is known that D_2O upsets normal hydrogen bonding, Dr. Gross infers that the proteins forming the strands are built up from simpler molecules by hydrogen linkage.

Analyzing Copolymer Systems

➤ A RAPID, vapor-phase chromatographic method for identifying acrylic polymers and copolymers as well as other resins has been developed by the National Bureau of Standards. With this approach, polymers can easily be characterized and as little as 0.2 percent copolymer can be detected. Acrylic copolymer composition can be quantitatively determined within ± 0.5 percent. The analysis requires relatively inexpensive equipment, needs only a small amount of material, and is readily adaptable for different copolymer systems.

Acrylic polymers and copolymers find many industrial applications as transparent plastic sheets, molding materials, and resinous coatings, as well as in prosthetic dental materials. Methyl methacrylate, often crosslinked with other materials such as ethylene dimethacrylate to modify its properties, is the main constituent of denture base resins, plastic teeth, and anterior plastic fillings.

Nuclear Approach to Particle Size

➤ A NEW instrumental technique for automatic particle size analysis — a nuclear achievement of primary importance for the many industries which have long searched for a precise, rapid, and economical method to measure particle size and distribution — was reported before the sixth annual meeting of the American Nuclear Society by Dr. Jane Connor of Evans Research and Development Corporation, New York City.

Under development in the Radioisotope Laboratory of Evans Research, an independent industrial research organization, under the sponsorship of the Office of Isotope Development of the U. S. Atomic Energy Commission, this unique nuclear-type analyzer is designed to overcome the many limitations of present day instrumentation and methods for the urgent problem of particle analysis. Intended for general use, both in industry and in the laboratory, this novel particle analyzer will be safe, non-destructive, and will be adaptable for continuous on-stream sampling, in dry or liquid state, without interfering or affecting the flow of production.

The theory of the Evans Research Automatic Particle Analyzer is based on a beta-ray, back scattering technique which measures the magnitude of fluctuations or the "spread" in a random sampling operation under specific geometrical conditions. Its source of radiation is Carbon 14. Its sensitivity range is from 1 to 500 microns and data is provided in a matter of minutes. This new instrumental approach has applications to any phenomena in which dispersions of fine droplets or solid particles are produced.

Examples of products or materials whose fate may hinge on fulfilling particle size specifications are: drugs, foods, cosmetics, plastics, paints, Portland cements, insecticides, electronics, rubber, explosives, fuels, soils, fertilizers, and ores. Particle size also has a vital bearing on natural processes relating to air pollution and water contamination.

For the food processor, particle control means quality control of the color, flavor, texture, consistency, and shelf-life of many ingredients. In the case of cements, the setting time, rate of pouring, degree of shrinking and cracking and ultimate tensile strength depends on particle size distribution. In certain drugs, such as pencillin and streptomycin, the ability to withstand long storage, to be resuspended after settling, and the rate of absorption of the crystals in the lymphatic fluids, are also determined by the particle size and distributions of the crystals.

Future application of this prototype Particle Analyzer is expected to overcome the disadvantages of commonly used methods which require considerable expenditure of manpower, are imprecise, severely limited in range, require removal of samples from the specimens and involve a long delay in securing data.

The products and processes involved in particle size and distribution represent a huge sum and a major segment of the national economy. The projected success of the Evans Research radioisotope Particle Analyzer is expected to save industry many millions of dollars.

Reservoirs of Sunshine

➤ A NETWORK of sunshine reservoirs, pools of salted water storing up the heat of the sun, can provide arid underdeveloped countries with an easily available and economic source of energy, an Israeli scientist has reported.

Dr. Henry Tabor of the National Physical Laboratory of Israel, authority on solar energy, reported on his new plan for "pooled" solar power to the scientists and statesmen meeting at the Weizmann Institute of Science for the first International Conference on Science in the Advancement of New States.

In the new scheme, salts would be dissolved in water at the bottom of a square pool, two-thirds of a mile on a side. Then the heat of the sun would concentrate and remain at the bottom because the heaviness of the salted water would prevent the heat from rising to the surface. The surface layer of the pool, however, would remain at a constant temperature since it would lose heat at the same rate it picks it up. The success of the operation would depend only on keeping the water in the pool undisturbed.

Construction costs are estimated at about $1,000,000. The investment would yield a return in heat energy valued at $250 per kilowatt, producing electricity at one-tenth the cost of any other solar apparatus to date.

Dr. Tabor does not believe the development and use of solar energy will be adopted by the developed areas of the world; but it may provide the economic independence so eagerly sought by the arid underdeveloped regions of the world which boast little else in the way of natural resources than the blazing energy of the sun.

Chemical Defenses

➤ THE BODY'S OWN chemical defenses, responding too violently to foreign substances, may be implicated in lung cancer.

This possibility is suggested by research in which cancer-causing agents —previously found in cigarette smoke, auto exhaust, and city air pollution — were injected into the windpipes of rats, according to Dr. Andrew L. Reeves, research associate in the department of industrial medicine and hygiene at Wayne State University. The particular carcinogens, or cancer-causing materials, used in the experiments were 1,2-benzanthracene and 3,4-benzpyrene.

At various periods after the injections, the rats' lung tissues were subjected to biochemical analysis to determine the distribution of certain chemicals in their cells. Comparisons were made with similar tests on rat lung cancer tissue.

The results seem to indicate that "a possible over-compensatory mechanism of the host cell — not necessarily located in the same area where the initial response to the carcinogen had taken place — may play a role in the development of the tumors," he asserted, adding:

"We believe we have pinpointed some of the initial phenomena during or preceding carcinogenesis."

The injections provoked an immediate response in the animals' natural defense mechanisms against foreign body invasion. Scavenger cells accumulated at the site of deposition, and in about 6 weeks most of the injected chemicals were largely cleared out of the lungs, the biochemist reported.

But the response did not all subside when the lungs had become free of the injected test substances. Some of the chemical changes continued to show up in later specimens of tissue, sometimes to an increased extent. In this "chronic phase" of the reaction some cell constituents were increased which are also increased in full grown cancer, he emphasized.

In other cases the response to the carcinogen involved an altered distribution of the constituent in different parts of the cell. But, interestingly, wherever, the cancer was characterized by a high value in the cell nucleus, the test specimens showed increase in one of the cytoplasmic fractions (outside the nucleus), and vice versa.

As a matter of fact, many cancer-producing chemicals act as potent growth inhibitors in tissue culture, which is exactly opposite to what one would expect from a carcinogen. Similar anomalies exist with respect to many other cancer-producing substances in the field of enzymatic action.

The phenomenon observed in our present study, where a carcinogenic challenge exerts its primary effect on a cellular constituent opposite to that which is involved in cancer tissue itself, provides another piece of evidence that cause-and-effect relations in cancer research are indeed complicated.

Dr. Arthur J. Vorwald, director of the Wayne State Laboratory, and Mrs. Dolores B. Dibley, a research technician, were coauthors of the report.

New Method Speeds Separations

➤ COMPONENTS OF solutions or suspensions can be separated in a matter of seconds, by a new electrophoretic method reported by Dr. Alexander Kolin, biophysicist at the University of California Medical School, Los Angeles.

The new method involves the use of electromagnetic forces in combination with an electric field to make ions of different mobilities follow divergent spiral paths.

The ions form very thin, sharp streaks, and separation is clearly discernible in some cases within one second.

One of the major problems of separation of components in free solution has been that of thermal convection. The heated fluid elements tend to rise mixing up the contents of the separation apparatus.

By electromagnetic rotation of the column containing the particles to be separated, thermal convection is inhibited.

To drain off the thin streaks of separated ions, a cylindrical peg can be placed in the path of ions. The streaks flow around the peg and can be withdrawn through channels in its side.

Preliminary studies were performed with different dyes and cell suspensions. Future plans call for investigation of possible separability of normal and cancer cells by this method. The work has been supported by the Office of Naval Research and the American Cancer Society.

Cleans Up Detergent Water

➤ DETERGENTS have been a pain in the neck to chemists involved in water purification. They have had no easy way of getting the washing chemicals placed in water upstream out of drinking water used downstream.

But Dr. I. M. Abrams reported that alkyl benzene sulfonates — the hardy part of detergents — can be almost completely removed from water by passing it through a plastic-like material A-102D, or Duolite. Dr. Abrams is a chemist with the Chemical Process Co., of Redwood City, Calif.

The removal process utilizes ion exchange in which a harmless ingredient of one compound is released in exchange for the material collected.

Alloy Works at 1,750 Degrees

➤ A NEW ALLOY that works at 1,750 degrees Fahrenheit is being used in the powerful engines of today's commercial jet planes. Developed at the Stanford Research Institute, the alloy is known as WI-52 and contains 13% tungsten. It lengthens engine life and improves fuel economy. Protective coatings of chromium and aluminum offset oxidation that occurs at this high temperature. Expected to have industrial tool and furnace applications, the new alloy supplants the older X-40 alloy, which has an operating peak of 1,600 degrees Fahrenheit.

A-Plants Now Competitive

➤ ELECTRICITY NOW CAN be generated economically with atomic power in some areas where conventional fuel costs are high.

A report prepared by the Atomic Energy Comission for the Congressional Joint Committee on Atomic Energy said competitive nuclear power now is possible with pressurized water reactors. This conclusion is based on quotations made to the Commission by reactor and core manufacturers. If started today, a 300,000,000-watt atomic powerhouse would be competitive over its lifetime in high-fuel-cost areas, the Commission said.

Water-cooled reactors "in the reasonably near future" may also be able to produce electricity at competitive prices in high-cost areas where large, single, powerhouse units are needed.

The Commission anticipates at least one more pressurized-water prototype power plant will be built. It is expected to incorporate technical advances learned from operation of the Shippingport (Pa.), Indian Point (N.Y.), and Rowe (Mass.), commercial nuclear power plants now in operation or being built. Design of such a plant could start in 1962.

Three boiling-water reactors are now planned. One manufacturer advised the Commission that a 300,000,000-watt plant of this type could be built now on a fixed-price basis and "may produce" competitive electricity in high-fuel-cost areas.

As for other reactor types, the Commission estimated competitive power in high-fuel-cost areas might be achieved by the middle 1960's for organic-cooled reactors, by the late 1960's or early 1970's for sodium-cooled reactors, and by the early 1970's for gas-cooled reactors using enriched fuel.

A greatly improved fuel element, however, must be developed before sodium-cooled thermal reactors will approach their economical potential.

Columbium Alloys Developed

➤ DEVELOPMENT OF NEW alloys of columbium that meet space age and nuclear requirements has been reported at a symposium on columbium metallurgy.

Columbium is one of the several relatively uncommon metals, such as beryllium, that have become increasingly important for atomic reactors and high-performance jet and rocket engines because of their peculiar properties at high temperatures. Extensive deposits of columbium ore were recently discovered in Quebec.

Alloys of columbium containing tungsten and titanium were found to resist oxidation at temperatures up to 2,550 degrees Fahrenheit, while maintaining good mechanical properties. Those containing aluminum and vanadium retain their low neutron cross section but have oxidation rates only a hundredth the rate of pure columbium.

Alloys containing varying amounts of titanium, molybdenum, chromium and zirconium were also investigated.

Refractory Single Crystals

➤ NEW USES for many highly refractory metals and some of their compounds may result from a new process whereby these materials may be obtained in the form of single homogeneous crystals.

Single crystals can be worked at significantly lower temperatures than are normally possible with refractory materials.

The Linde Company, a division of the Union Carbide Corporation, reported the crystals are at present produced as cylinders a quarter of an inch in diameter and a few inches to over a foot in length.

Complete details of the process are being withheld. However, it is similar in some respects to the Verneuil process for making synthetic sapphires. In this process alumina (aluminum oxide) together with a little coloring matter, is slowly fed as a powder through a very hot combustion flame where it melts and collects on a pedestal below. This pedestal is slowly lowered as the crystal builds up and a long cylindrical crystal, called a boule, results.

One of the main advantages of the Verneuil flame fusion process is that no container is required for the molten substance. This advantage is reported to be retained in the new process. The heat source, however, is an electric arc rather than a chemical flame, allowing a wider range of temperatures and atmospheres to be used.

Materials so far produced as single large crystals by this process include tungsten, molybdenum, vanadium, columbiun, and tantalum among the pure metals, and titanium carbide, titanium monoxide, titanium sesquioxide, and molybdenum disilicide among the compounds.

Moisture Content Dates Obsidian

➤ A NEW METHOD has been found to determine the age of objects made from obsidian, or volcanic glass, that is more than 100,000 years old.

This archaeological dating method was accidentally discovered when two scientists set out to prove that the water contained in volcanic glass is absorbed from the outside and is not originally present in the glass when formed.

The surface of obsidian begins to absorb water as soon as it is formed. The older the obsidian gets, the thicker the hydrated layer becomes. To determine the amount of time it had taken for the obsidian to absorb a layer of moisture, Drs. Irving Friedman and Robert L. Smith of the U. S. Geological Survey used ancient man-made objects that had already been dated by carbon-14. Once the hydrated layers in objects of known age were measured, it was possible to date other objects by measuring the thickness of the hydrated layer on their surfaces.

One factor that determines the rate of hydration is temperature. The scientists believe that the hotter a climate is, the faster the obsidian surface will absorb moisture. Other factors to be investigated are relative humidity of any given area, and the chemical composition of the obsidian. The method is also useful for detecting fake artifacts.

Colorful Motoring Ahead

➤ A TRULY BRIGHT day for motorists is forseen in the near future, when colored highways may replace the monotonous grays and blacks that are traveled today.

Thermoplastics, made from petroleum gases and mixed with an aggregate such as rock or sand, can be produced in any color. The mixture is rolled and applied as a one-inch surface on pavement already laid. The colors are expected to make it easier to follow highway routes. Colored curbing also is planned to clearly define road boundaries to lessen the danger of running off on a soft shoulder, and to warn of intersections and other danger spots.

Tests on the newly-developed materials, which employ the highly-versatile plastics, polypropylene, polyethylene and polyisobutylene, are underway at the research center of the Esso Research and Engineering Co., and are almost ready for full-scale experiments on heavily traveled highways and on airport landing areas.

The colored road coverings are expected to prove of great importance to aviation, as they not only identify different landing strips but will serve as a guide to private pilots who follow familiar landmarks, such as highways.

Resistance to oil is expected to make the new plastic material valuable to fueling and repair areas of airports, garages, gasoline service stations and other operations where oil-soaked surfaces are potentially dangerous.

In painstaking experiments, the paving materials were subjected to the Marshall Stability Test, where core-like samples were placed in a testing machine under 140 degrees Fahrenheit temperature and tested under various pressures, measured in pounds. For light or medium applications 500 pounds pressure is used; for heavy use, 750, for very heavy use, 1,000 and for airport applications 1,800 pounds.

New formulations have reached stabilities from two to three times higher than these standards.

Under the Marshall test, a 1,000-pound rating equals from 100 to 120 pounds per square inch. A 20-ton truck exerts pressure of about 70 pounds per square inch.

Standard Radioactive Symbol Adopted

➤ A THREE-BLADED, purple propeller on a yellow background, the symbol now used by the Atomic Energy Commission and many state health agencies to warn of the presence of radiation, has been adopted as the official radiation symbol of the American Standards Association.

The symbol is intended for use on signs at the entrance to rooms or areas where sources of radiation are present; on bottles, containers and packages of radioactive materials; on X-ray equipment and other machines that generate radiation, and on materials or apparatus contaminated with radioactive substances.

New Theory Extends Relativity

➤ A PHYSICIST has proposed a new theory extending the theory of relativity to account for the internal structure of such elementary particles as electrons and protons.

In his theory, a part of which will be published later in the journal Physical Review, the scientist argues that a particle moving from one point to another in an electromagnetic field undergoes changes in its dimensions.

The theory is the product of Dr. Lloyd Motz, an associate professor of astronomy at Columbia University. He is the author of "This Is Astronomy" and "Outer Space."

Dr. Motz said modern physicists have treated the particles as points that do not change dimensions. He believes they are wrong.

His theory, he said, shows how an electron is held together and accounts for the capture of light by the electron.

Dr. Motz has demonstrated that, by making certain assumptions about the way in which the dimensions of the particle can alter when it moves in various paths, several of the well-tried, older equations that govern the properties of particles may be derived.

He has shown, for example, that the second order Dirac equation, a fundamental equation in modern wave mechanics, can be derived from his theory.

"Star Dust" Contains Coesite

➤ THE "STAR DUST" sold in souvenir bottles at the meteor crater near Canyon Diablo in Arizona contains a rare material, coesite.

Previously, coesite was made only in small quantities in laboratories, by squeezing silicon dioxide (common quartz) under extremely high pressures. The discovery that coesite occurs naturally under high pressures was made by Edward Chao of the U. S. Geological Survey.

If the moon's craters were also made by the impact of meteors, as many scientists believe, then chances are good there are diamonds on the moon. The diamonds would be produced under the extremely high pressures generated when meteors smashed into the lunar surface. The high pressures cause crystalline changes, such as occur when graphite is changed to diamond or quartz to coesite.

Except for meteor craters and small laboratory quantities coesite is believed to exist on earth only at depths below 40 miles.

Geologists believe that coesite might be discovered on the earth's surface if a careful search were made. This would mean that the rocks in which coesite was found had been carried from great depths to the surface in times long past.

Scientists at both the Carnegie Institution of Washington and the University of California at Los Angeles, among others, have prepared coesite in the laboratory. They have instruments that duplicate conditions under which rare materials are formed at extreme depths.

Museum Gets Black Diamond

➤ A BLACK DIAMOND weighing 740 carats and believed to be the largest ever found in French Equatorial Africa has been presented to the Smithsonian Institution, Washington, D. C. Black diamond, also called carbon or carbonado, is an opaque, black, tough and compact variety of diamond that is found primarily in French Equatorial Africa and Brazil. It is the most satisfactory form of diamond for diamond rock drilling, and its relatively limited use is due chiefly to its comparative scarcity. The black diamond gift was made by Diamond Distributors, Inc., and is believed to be the largest mass of black diamond in any museum in the world.

Dialdehyde Starch Strengthens Paper

➤ PAPER with increased wet strength has resulted from a new method of treating paper pulp with dialdehyde starch, made from corn, wheat or grain sorghum.

Scientists of the U. S. Department of Agriculture have found that dialdehyde starch at levels of 0.5 to 2.5% in pulp produced papers with excellent wet strength and with better dry strength than that of untreated paper.

Uses for wet strength paper include paper toweling, toilet and facial tissue, outdoor posters, shipping sacks, grocery bags, frozen food wrappers, and photographic and filter papers.

New Solar Cells Made

➤ A NEW KIND of solar cell that serves as its own storage battery has been reported.

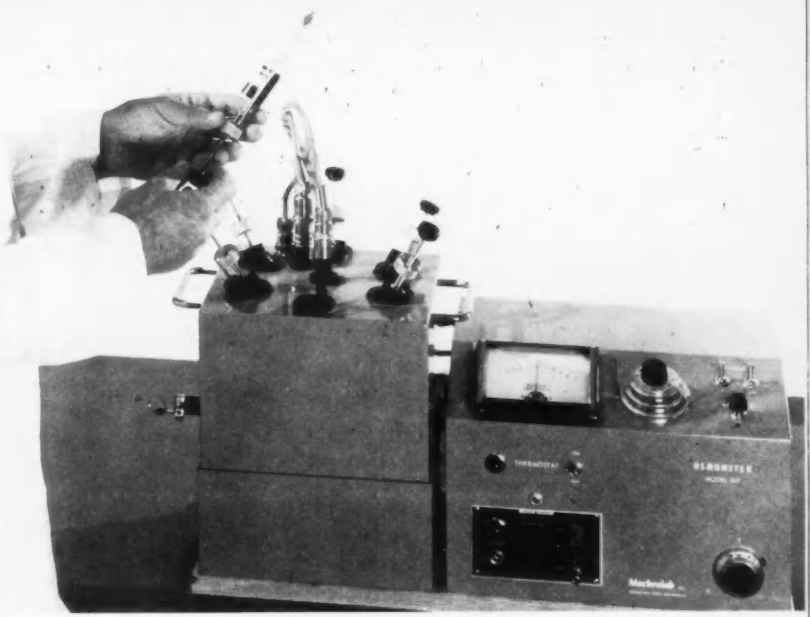
If it fulfills its apparent promise, the cell will make obsolete solar cells now powering American satellites. These older cells require heavy storage batteries to store the electricity converted by the cells from sunlight.

The new cells convert solar energy directly to chemical energy. The solar cells themselves store the chemical energy for later conversion to electrical energy.

Bert H. Clampitt and Dale E. German of the Wichita, Kans., division of the Boeing Airplane Company built the experimental cells.

Index Chemicus

➤ THE FIRST copies of Index Chemicus, a monthly listing of the new chemical compounds reported by scientists all over the world, have been published. More than 60,000 new chemicals are reported each year in scientific literature and few scientists can hope to scan the total coverage of even a limited field. Index Chemicus lists each new compound by name, molecular formula, and structural diagram, and gives in addition the original journal reference and author. New chemicals appear in Index Chemicus within 30 days of being published in the original journal.



Apparatus Article

Molecular Weight Apparatus

➤ An easy-to-operate device for the accurate determination of molecular weights of unknown materials in solution has been developed by senior physical chemist R. A. Pasternak and chemist Leonard A. Cavanagh of Stanford Research Institute. The efficient analytical tool is also valuable for research on interactions of compounds in solution.

Key to the instrument is a thermostated chamber wherein the atmosphere is saturated with the vapor of a solvent. A probe composed of two bead thermistors is enclosed. Drops of the solvent and of the sample solution are applied to the beads through one of the six syringe assemblies of the unit.

At any given temperature the vapor pressure of a solution is lower than that of the solvent. Therefore, the solution drop warms up (by condensation of minute amounts of solvent) until pressure balance between the two drops is attained. The temperature rise, detected by the thermistor probe, is about proportional to

the "osmotic concentration" of the sample solution. When the instrument is calibrated with solutions of known concentration, it is then possible to calculate the molecular weight of the unknown solution.

The new instrument, which was developed for Mechrolab of Mountain View, California, has great advantages over current molecular weights devices. Because of the syringe assembly, it does not have to be opened after each sample. Duplicate readings can be taken on fresh samples within 1 to 5 minutes. An accuracy of 1 to 2 percent can be obtained routinely. Moreover, only very small amounts of the sample are required for testing, and even these can be recovered if desired.

√ *Chemistry Quiz* √

Directions: Mark the answers you think *most nearly correct.*

Answers are on page 29.

A. The Tunnel Diode is
1. a transistor
2. a resistor
3. a semiconductor
4. an open passageway
5. a double radio tube

B. The pi-meson does not
1. leave a track in a photographic emulsion
2. occur in the nucleus of an atom
3. decay to form two photons of light
4. have as long a lifetime as other elementary particles
5. have a measurable lifetime

C. Nitric acid reacts with
1. all metals to form hydrogen
2. hydrogen to produce water and nitrous acid
3. benzene to form an oxide
4. glycerine to form soap
5. aqua regia

D. Synthetic diamonds are produced by
1. dissolving carbon in water and evaporating to dryness
2. treating carbon with heat, pressure and a metallic catalyst
3. treating carbon with a rapid stream of neutrons
4. dissolving quartz in molten iron
5. compressing corundum under high temperatures

E. Aluminum was first used for military purposes
1. in the armies of Alexander the Great
2. in the armies of Julius Caesar
3. in the armies of Gengis Khan
4. in the armies of the United Nations
5. in the armies of Napoleon

Proudly Presented

Announcing new developments in the chemical industry and newly available chemical literature.

New Butylene Glycol Facilities

➤ Celanese Corporation of America announced that it is constructing in Bishop, Texas, the nation's first full scale commercial facilities for producing 1,3-butylene glycol, a chemical used by the plastics, automobile, electrical and other industries for making a wide range of consumer and industrial products.

The multi-million dollar unit will have an annual capacity for producing 25,000,000 pounds of the chemical by a new process developed by Celanese. This is an increase of five times over the current capacity for producing the chemical in a semi-works unit at the Celanese chemicals plant in Bishop.

Construction of the new unit is expected to be completed during the first quarter of 1961. Celanese is the sole U. S. producer of 1,3-butylene glycol.

This latest major expansion in the continuing Celanese program of diversification in chemicals has been prompted by growth in established uses and in a number of new applications for 1,3-butylene glycol. The chemical is well established for use in plasticizers for polyvinyl chloride in such applications as high temperature insulation for electrical wires, trim for the inside of automobiles and as ease-of-care upholstery coverings. In applications of this type, plasticizers containing 1,3-butylene glycol provide permanence on exposure to high humidity and temperature, as well as resistance to corrosion and to extraction by soaps and oils.

In addition, the chemical has shown favorable properties for inclusion in resins for boat hulls, construction materials and other applications requiring toughness and stability.

Some of the other uses for the chemical are in gasoline and lubricating oil additives, printing inks, ballpoint pen inks, textile lubricants, dyes, toilet goods, and tobacco humectants.

Heat Developed Recording Paper

➤ Development of photographic paper in less than three seconds using only a heated chamber was reported by Paul H. Stewart, William Borneman, and W. B. Kendall of Kodak Research Laboratories at the Rapid Processing Symposium of the Society of Photographic Scientists and Engineers in Washington, D. C.

The new silver-sensitized, oscilloscope-recording paper has chemicals for development incorporated in the photographic emulsion. Development begins as soon as heat is applied.

In practice, enough water is contained in the emulsion support for complete processing, Kendall explained.

The processor is a heating chamber enclosed except for slits at front and back for exposed paper to enter and leave. Moisture driven from the pho-

tographic emulsion and paper support condenses on the cool surface of the entering emulsion. The combination of heat and moisture processes the paper in less than three seconds.

A few drops of water in the chamber, or passage of about five feet of recording paper through it, will prime the processor for rapid development, Kendall said.

The new paper, called K-1549, is fast enough for exposure in oscillograph recorders with high-intensity mercury lamps.

Oscillograms made with the paper have remained readable for months under reasonably dry conditions. For greater permanence the prints may be stabilized or fixed by conventional methods, Kendall said.

Chemically Modified Cellulose Dielectric

➤ A NEW FILM-FORMING and moldable dielectric that has the highest dielectric constant (12.5) of all known organic film-forming materials has been developed by American Cyanamid Company.

Because of its high dielectric constant and its low dissipation factor, Cyanamid's new product, Cyanocel chemically modified cellulose, provides a capacitance per unit volume two to six times greater than that of other comparable products.

Electroluminescence and microminiature capacitors are two known applications. Its first commercial use will be in an electroluminescent lamp made by General Electric Company. The unique electrical properties of this dielectric, however, are expected to be advantageous in other areas.

A white, fibrous solid, Cyanocel is made by cyanoethylating a highly refined form of cellulose with acrylonitrile. Through techniques developed by Cyanamid research, the company has been able to modify 2.6 to 2.8 of the three available hydroxyl groups on each gluocosidic unit of cellulose with a cyanoethyl group.

New Ag Chemical Research Center

➤ THE NEW Agricultural Chemical Research Center at The Dow Chemical Company has been formally opened in Midland, Michigan.

The new center will house all activities related to agricultural chemicals research at Midland. The building provides more than 50,000 square feet of laboratory and office space in addition to greenhouses and service buildings. The center is located on a 110-acre farm dotted with field test plots, animal barns and corrals, an orchard, and woody plant nursery.

The new facility is a major operational unit as well as headquarters for Dow's national network of agricultural research facilities, including the Texas Division laboratory at Lake Jackson, the Western Division laboratory at Seal Beach, California, and research field stations in Florida, Mississippi, northern California, and Michigan.

Dow, a leader for many years in the field of agricultural chemicals, produces herbicides, animal health products, fertilizers, soil fumigants, insecticides, and space and grain fumigants.

Synthetic Rubber For Backsizing

➤ PLIOLITE 176, a synthetic rubber latex with special qualities that prescribe its use in textile backsizing operations, has been introduced by the Chemical division of The Goodyear Tire & Rubber Company.

Upholstery and carpet backings and sizings for mattress ticking are especially recommended areas of use for this butadiene-styrene latex.

It is a versatile material that can be compounded to meet a wide variety of conditions, and it contains a non-staining anti-oxidant system. It can be used with or without a cure, depending on the desired end-use properties.

The new latex has outstanding heat and light aging properties and imparts soft hand in end use applications. It has excellent stability and forms tough, flexible, low-odor films that have practically no tackiness.

New Metal Protective Coating

➤ A NEW CHEMICAL surface treating process, which for the first time color coats all types of metals in a single treatment, is now ready for commercial application, Pennsalt Chemicals Corporation announced. Called the Hinac Process, the new coating is produced in several grades, clear and colored, which are corrosion resistant, have good weathering properties and are color fast. The process combines ease of application with good corrosion resistance at economical cost.

The Hinac Process, which is being shown now to the metal trades for the first time at the 1960 National Metals Exposition and Congress in Philadelphia, will be marketed nationally to all types of metal processors and fabricators. Hinac coatings can be applied readily to practically any metal, producing attractive satin and color finishes. In addition to being resistant to acids, alkalis and solvents, Hinac color coatings are considerably more economical than color anodizing or painting.

World's Largest Cumene Plant

➤ ONE OF THE largest cumene plants in the world was put on stream by Texaco Inc. at its Eagle Point Plant in Westville, New Jersey.

Cumene, once used as a high-octane blending stock for aviation gasoline, is now an important raw material for the chemical and plastics industry. Cumene was manufactured during World War II to help meet the military need for large quantities of enriched aviation fuel. Since that time, however, it has become one of the principal raw materials for producing the synthetic phenol and phenolic resins that help make up many common household plastics, textiles, detergents, pharmaceuticals, germicides, and adhesives for bonding plywood.

Texaco's new plant, which has a capacity of approximately 70 million pounds of cumene per year, will help the chemical industry to meet the increasing demand for synthetic phenol.

Texaco will make its cumene from propylene and benzene, both petroleum-based raw materials. Though the use of cumene as a raw material for making phenol did not begin until 1953, it has steadily become one of the major sources for world-wide phenol production.

Organized New Research Laboratory

➤ ORGANIZATION of a new laboratory group for basic use research on chemical products was announced by The Dow Chemical Company, Midland, Michigan.

The new laboratory will be headed by Harold A. Robinson and will concentrate on basic studies involving the function of chemicals needed for specific end uses such as lubrication, heat exchange and corrosion control.

Such studies will provide the specifications for chemicals capable of better serving desired end uses, and when coupled to supporting research in materials and chemical synthesis, will extend the range of applications for existing products and broaden Dow's chemical products line by the introduction of new and superior products.

Construction of a new building to house the laboratory is scheduled for completion by early 1961 in Dow's research center at Midland.

The new laboratory group will have functions corresponding with existing laboratories in Dow's plastics, magnesium, and agricultural chemicals department.

Caffeine-C-14 Available

➤ IT WAS ANNOUNCED recently that a new radiochemical compound, Caffeine-C-14, has been made commercially available by Tracerlab. Caffeine, usually classified as a stimulant, is a normal constituent of coffee, tea and other organic materials, and is used in its pure form for various medical purposes.

It is expected that the new compound will help medical and biochemical researchers in gaining a deeper understanding of the effects of caffeine on cardiac, respiratory, and psychic functions.

Available exclusively from Tracerlab, Caffeine-C^{14} is chemically known as 1-Methyl-C^{14}-3, 7-Dimethylxanthine. It is priced at $450.00 per millicurie; $45.00 per 100 microcuries, and $40.00 for the AEC license exempt 50 microcurie "E-Q Pak."

Tertiary Amines From Propylene Oxide

➤ A NEW GROUP of aliphatic chemicals called Propomeens has been developed by the Armour Industrial Chemical Company. The chemicals, available in pilot plant quantities, represent a new family of tertiary amines whose properties should augment currently available high molecular weight amines.

The new products are propylene oxide adducts of aliphatic amines prepared by adding propylene oxide to Armeen CD, Armeen HTD, coco amine and hydrogenated tallow amine, respectively.

Propomeen chemicals are suggested for research and development in applications requiring oil soluble amines and cationic surface activity. It is also expected the Propomeens will be useful as dispersants in hydrocarbon systems, defoamers in acid systems and as oil additives.

Additional information may be obtained by contacting Armour Industrial Chemical Company, 110 North Wacker Drive, Chicago 6, Illinois.

Gas-Cooled Reactor Uses Helium

➤ A GAS-COOLED nuclear reactor now being built is expected to leapfrog some drawbacks of existing atom plants and land close to the electric utility industry's goal of generating economic power with atomic energy.

The High Temperature Gas-cooled Reactor (HTGR) on the Susquehanna River in southeastern Pennsylvania, is to be completed in 1963. Its development and operation is expected to show short-cuts to competitive electricity production using atomic fuels.

Dr. Peter Fortescue and Corwin L. Rickard of General Dynamics Corporation's General Atomic Division in San Diego, Calif., told an American Nuclear Society symposium that high performance is expected from this prototype plant because it is technically simple and compact.

Its hot core will heat the helium gas coolant to 1,380 degrees Fahrenheit, enabling steam to be generated at 1,000 degrees and pressures of 140 pounds per square inch or higher.

The 40,000-kilowatt prototype is being built for 53 private utilities in 31 states and the District of Columbia. It will have a high degree of inherent safety.

This prototype itself is not expected to produce a kilowatt-hour for seven mills, but rather to show the way to short-cuts that will lead to economic, 300,000-kilowatt nuclear power plants.

Participating in the symposium were nuclear experts from England, Australia and Russia, as well as from U. S. industry and Government.

Strong Plastics Repair Roads

➤ REPAIRS in concrete California highways are being made with plastics so strong they hold even when the concrete itself breaks.

Bailey Tremper, supervising materials and research engineer for the California Division of Highways, told an American Concrete Institute's meeting that epoxy resins form "strong, chemically resistant structures having remarkable adhesive properties." A recent product of chemistry, the resins have long, crosslinked molecules that provide great strength.

Mr. Tremper said his division, as far as is known, first discovered "that epoxy adhesives will form a strong, durable bond between fresh plastic concrete and old, hardened concrete."

In one application, holes are coated with the resins and fresh concrete poured in. The repair thus made is strong and more economical than the resins used for the whole filling job.

Mr. Tremper said California installations have proved the durability of the resins in areas of mild weather. Only recently have they been tried in locations where winter temperatures fall below zero. Mr. Tremper said he is "not prepared to state at this time that the typical formulation yields adequate flexibility for exposure to cold weather."

Dow

This is the fourth of a series of eight articles to be presented in CHEMISTRY this year. Many of the students now preparing for a career in chemistry will eventually join one or other of the large corporations and this series, featuring eight of the major companies employing chemists in the United States, is intended as a preview into the type work that they will be doing.

➤ SOMEONE HAS SAID, "Man is not the only animal who labors; but he is the only one who improves his workmanship. This improvement he effects by Discoveries and Inventions."

The fruits of these discoveries and inventions, brought about by what we now term research, are being harvested in every corner of the world. Today we find a research consciousness across a broad front such as was never dreamed of 20 years ago. The 10 billion dollars spent for government and private research and development in 1958 was larger than the total cumulative expenditures for those purposes up to 1944.

The American tradition of research was born in the Yankee ingenuity which gave our forefathers the Colt revolver and the Winchester rifle, among other inventions which speeded the settling of the country. This tradition, fostered by scientific freedom and encouraged by profit incentive, is today the strongest ever known.

Industry has played, and is playing, a major role in research contributions to man's progress. One of the reasons is that through its mass marketing techniques it can justify the gathering and organization of tremendously varied scientific skills and disciplines. And it provides something more: the resources for financing, testing, producing and distributing the offspring of men's minds.

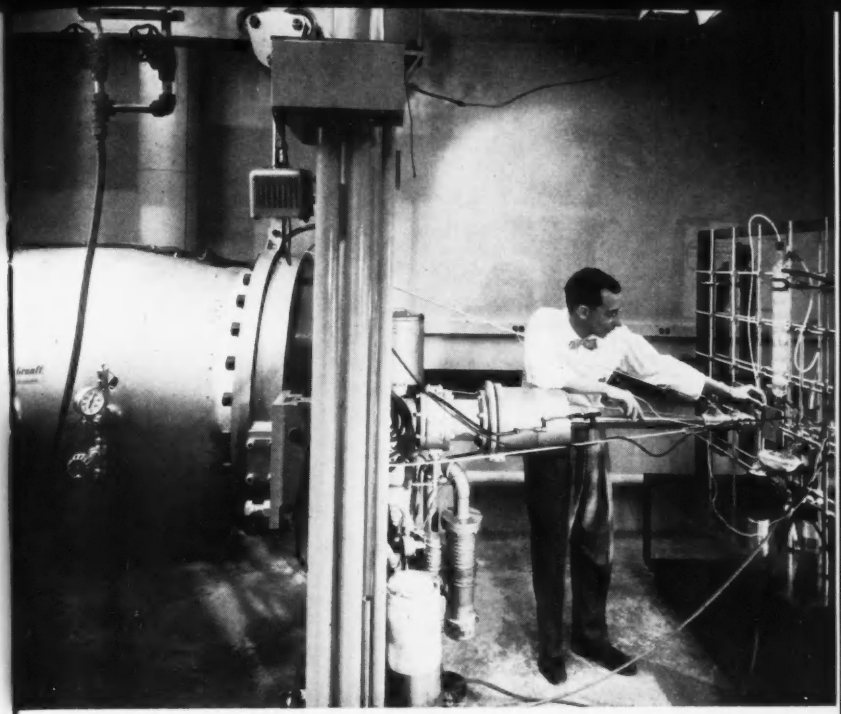
In our economy, the contributions of science can be distributed widely providing they meet society's standards for usefulness. Thus the scientist and the businessman share an ideal: thinking in terms of human wants is a key both to scientific progress and to dollars and cents of sales.

The ultimate purpose of industrial research is to determine these human wants and create the products to satisfy them. And although in recent years the objectives of research have become much more clearly defined, the motives for invention have always been the same.

Dr. Dow

It is of great significance that when the late Dr. Herbert H. Dow came to Midland in 1890 his purpose was to develop a better and cheaper method for making bromine. And throughout his career there was scarcely a single phase of the company's entire operations where the influence of one of the chemical industry's most research-minded individuals was not felt.

A former Dow research director

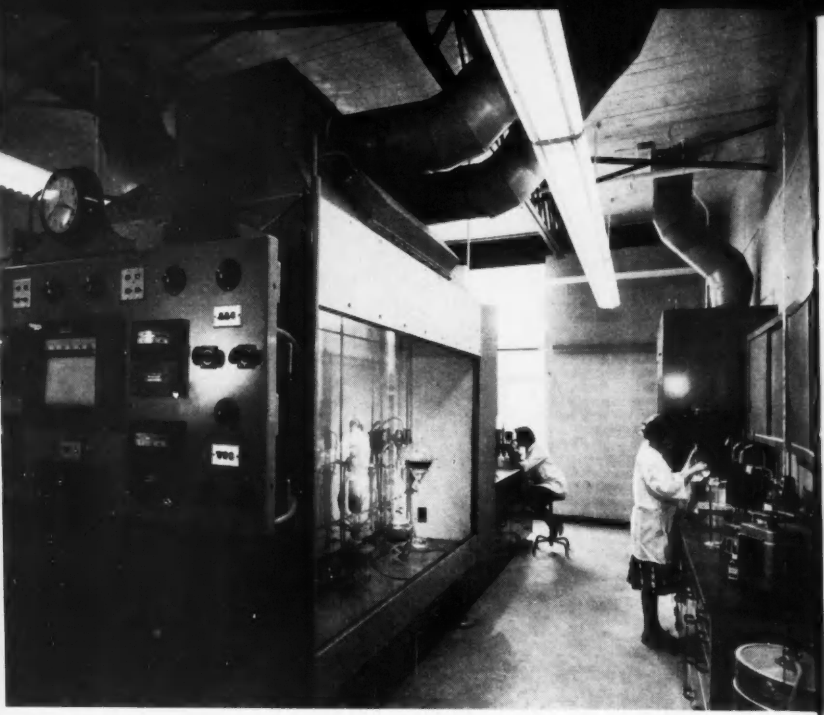


➤ SHOWN HERE *is the Van de Graaff accelerator used by The Dow Chemical Company as a source of nuclear radiations for research. The installation was one of the first in industry. Here a Dow scientist is preparing an experimental chemical reaction for activation by electrons from the machine.*

and member of the Board of Directors for many years, recalls in some of his writings Herbert Dow's answer to the question: to what did he owe his commercial success? According to Dow, it was being right more than he was wrong.

The philosophy inherent in this statement has always been, and still is, basically that which governs Dow research. As one of the company's division research directors has said, "Perhaps the key to productive research is to be an integral part of a 'progress' company willing to take a calculated risk."

That this "calculated risk-taking" has paid off for Dow is evident by the record. In a decade research, development, production and sales groups, working together, created 13,000 new jobs in The Dow Chemical Company. In a recent five-year period, the company built 22 modern major laboratories or additions to laboratories.



➤ SYNTHESIS *is a key word in agricultural chemical research carried on by The Dow Chemical Company, a pioneer producer of chemicals for agriculture. In this organic synthesis laboratory at Dow's Midland, Mich., Agricultural Research Center, research is directed toward creating new and useful materials such as weed killers, animal health products and other farm chemicals.*

In the early days of the company Dow literally forced his staff into new developments. A noteworthy example is the famed phenol process, which makes use of plentiful chlorine and which was considered impossible to operate on a commercial scale.

A former director of the organic research laboratory relates that Dow gave his chemists and engineers seven years — the estimated length of time after World War I that it would take to use up the surplus stock of phenol — to develop the process. The "impossible" process was operating by 1923.

By his inspiration Dow was able to instill this appreciation of research in the other members of his management staff — an appreciation which remains undimmed today. In any company, research cannot thrive with-

out top-level encouragement. At Dow, more than half of the company directors have been personally active in research at some stage of their careers.

This understanding by management of the importance of research probably accounts for two characteristic and significant attitudes at Dow: first, that "centralized planning, while important for efficiency, does not eliminate the essential place of individual judgment," and second, that research should not be, and is not, confined to laboratories.

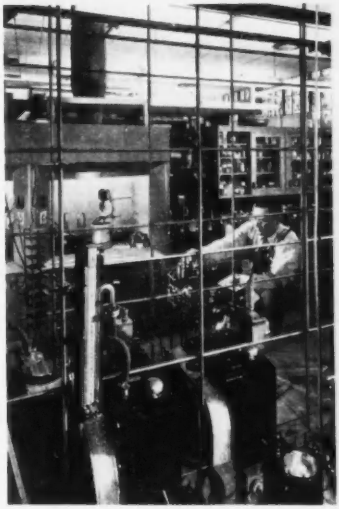
It all adds up to the belief that research cannot be separated from the other Dow operations. The philosophy and character of the research program is that of the entire company.

This philosophy does not mean, of course, a lack of organization and planning in research.

While much of Dow research cannot be neatly boxed and labeled, from the standpoint of organization it falls into three broad categories. This relatively simple organization structure allows the company to accomplish its research objectives without restricting freedom of thought or action.

Research Laboratories

Independent laboratories have the primary objective of long-range research of a company-wide nature where the results obtained are likely to apply broadly to many divisions and departments of the company rather than to a specific area or product. Examples are the E. C. Britton Research Laboratory (organic), the Electrochemical and Inorganic Chemical Research Laboratory and the Biochemical Research Laboratory.



➤ SCENE *in the Physical Research Laboratory of The Dow Chemical Company. In this laboratory much of the exploratory and development work on the Dow plastics Styron and saran was done. Other accomplishments include ion exchange resins; Styrofoam (Dow plastic foam); a special acid used by Dowell Division of Dow for treating oil and gas wells to increase their production; and many new and improved processes for making chemicals.*

Production Division laboratories are responsible for process and product improvement research and for the research necessary for each individual production location. Examples of production division laboratories are the Organic Process Development Laboratory in the Texas Division, the Research Department at the Western Division in California and the Plastics

Production Laboratory in the Midland Division at Dow headquarters in Midland, Michigan.

Product Department laboratories are primarily responsible for applications research and for the research essential to expand the various product areas which they represent. The company's product departments are divided into five groups: chemicals, plastics, agricultural chemicals, metals and textile fibers. The Metallurgical Laboratory, the Agricultural Chemicals Research Laboratory, and the James River Research Laboratory (textiles) in Virginia are examples of product department laboratories.

The company believes that research should rub elbows with production and sales. Accordingly research units are distributed throughout the various operating divisions. More than two score distinct research laboratories are maintained in the United States and Canada — from Framinghom, Massachusetts, to Seal Beach, California, and from Midland, Michigan, to Freeport, Texas.

This network of research facilities has grown from one facility, back in 1918, when the first laboratory built especially for research — the Organic Research Laboratory — was opened.

The modern laboratories are designed and equipped to make the best use of the research man's skills, to give him more hands to work with. At his command are such instruments as mass spectrographs, infrared absorption spectrometers, Van de Graaff electron accelerators, cobalt 60 radiation sources, ultracentrifuges, nuclear magnetic resonance equipment and high-speed electronic computers. A considerable amount of research equipment has been built in the company's own shops.

Emphasizing the importance of this instrument development, one laboratory director points out that Dow has been one of the first companies to realize that new physical methods, besides being the most rapid and efficient methods of analysis, also provide a new insight into the nature and behavior of chemical substances. Many of Dow's new products and new processes were invented because new instruments made new scientific information available.

Behind the research man is an imposing array of "backup" people and services — glass blowers, electricians, construction men, machinists, pipefitters and welders. Working with him are technicians, patent experts, librarians, market research and economic evaluation specialists, engineers, analysts and a group devoted to research information, the Central Research Index.

With all this support behind him the research man at Dow may take one of several routes in determining human wants and in creating the products to fill them. He may probe the unknown for scientific data — fundamental research, he may create new products and uses for them, he may develop new processes for making these new products, he may determine new uses for existing products or he may improve existing processes and products.

The nature of Dow's work is such that a great variety of problems, some of great fundamental interest, others of great practical urgency, may be expected to contribute to company growth.

Experimentation

Whether a project is fundamental or highly practical, experimentation serves as a unifier and generator of ideas.

Here is how it works in practice:

At the exploratory stage, research people are encouraged by research management to experiment on projects mutually considered worthwhile — and to pursue ideas.

Before reaching the pilot plant stage, where capital and operating costs are likely to be high, promising projects are given careful business evaluation. With the help of other departments such as production, economic evaluation, market research and sales, they are considered in terms of technical readiness, market potential and profit.

Over the long pull, Dow researchers look for new ideas for products useful to society and select from them the ideas which can be efficiently put to use by the company.

Today many hundreds of college-trained men and women, representing about 40 scientific fields and more than 100 colleges and universities, are at work in Dow research laboratories.

Products of Dow research "new" within the last five years accounted for slightly more than 10% of total sales during 1960. This represented the attainment of a research objective of several years' standing and believed desirable to insure the healthy growth of the company.

Of 88 products introduced in the five-year period, 18 produced sales of a million dollars or more during 1960.

Coupled with this were two other significant accomplishments. The number of new products introduced to the market during the year totaled 24 — the largest number ever to qualify for the new products list in any one year.

Further, the average time for a product to travel from laboratory to market was reduced to four years. In 1959 this average time was five years, and in 1957 eight years. This progressive reduction, also a major company objective, has been accomplished through pointing the research organization toward better selection of projects, more effective use of facilities including pilot plants, computers and automatic data-taking equipment, and more effective communications among all segments of the company involved in bringing a product to market.

Whatever the accomplishments of a given year, the objective at Dow continues to be better research leading to better processes and products — contributions which will help to give all people a growing measure of control over their physical environment and their destinies.

√ Answers to CHEMISTRY QUIZ on Page 18. √

A - 3; B - 4; C - 2; D - 2; E - 5.

For the Home Lab

Nitric Acid

by Burton L. Hawk

➤ After considering sulfuric and hydrochloric acids, it is mandatory that we now include nitric acid. After all, one does not discuss two of these acids without the third. That would be a breach of chemistry etiquette!

First, let us commence with the all-important warning. Nitric acid causes severe and painful burns which are exceedingly difficult to heal. Therefore it is absolutely necessary that you exercise extreme caution in performing the experiments outlined here. Avoid spilling the acid on your skin or clothing. Work carefully and neatly and you should have no trouble.

Obviously, nitric acid is an acid. But, it must be remembered, it is also an active oxidizing agent. Fill a test tube about one-third full with concentrated nitric acid. In the mouth of the tube, insert loosely a plug of woolen yarn; or hang a thread of woolen yarn on the mouth of the tube allowing it to hang inside the tube about half inch down from the top. Apply gentle heat. Continue to heat carefully and evenly until the acid boils. The vapors will ignite the yarn which will burn vigorously. (Do not allow the hot acid to spurt out of the tube and keep your face away. Hot nitric acid is particularly dangerous!) If a piece of glowing charcoal is immersed in concentrated nitric acid it will continue to burn. *Please do not try this* . . . just take our word for it. There is too much danger from spattering nitric acid.

The oxidizing power of nitric acid complicates the reaction with metals. With the other two acids, we simply get hydrogen; with nitric acid we get a variety of oxides of nitrogen depending upon the concentration of acid. For example, add a piece of zinc to a small quantity of concentrated nitric acid in a test tube. The action is vigorous and the tube is quickly filled with deep brown fumes. This is nitrogen dioxide. In another tube, add 2 cc. of nitric acid to 10 cc. of water and drop in a piece of zinc. Colorless nitric oxide is obtained. You may note some light brown fumes as a portion of the nitric oxide will combine with the air to form nitrogen dioxide. In a third tube, add 5 cc. of nitric acid to 50 cc. of water. Drop in the zinc and apply heat until the action is fairly vigorous. After a short while, sniff cautiously at the mouth of the tube. Can you detect a sweetish odor? This is nitrous acid (laughing gas" or "sweet air").

Can we ever obtain hydrogen from nitric acid? Yes, by using magnesium metal with very dilute acid. Place a few pieces of magnesium ribbon in water in a test tube. Add only enough nitric acid to cause effervescence. Hydrogen is evolved. If you obtain brown fumes, your solution of acid is too strong.

Nitric acid will disolve many metals that resist other acids. We assume that the metal is first oxidized and then the oxide is dissolved. Note we mentioned "assume". The complex

reactions of metals with nitric acid are still not fully understood. One theory is that hydrogen is set free but is immediately oxidized to water by the nitric acid. But how about the hydrogen obtained with magnesium? No doubt temperature and concentration of acid depend upon the products we obtain, whether it is nitrous acid, nitrogen dioxide, nitric oxide, nitrous oxide, nitrogen, ammonia, or hydroxylamine. Nitrous acid is invariably formed as the primary product and the others from the nitrous acid by further action. Questions: Copper is attacked vigrously by nitric acid; but if the nitrous acid also formed is removed, the metal is inert to nitric acid. Why? On the other hand, the presence of nitrous acid actually *retards* the action of some metals such as magnesium and cadmium. Why? Another example: Cadmium is attacked violently by concentrated nitric acid. However, if the cadmium is brought into contact with platinum (such as a platinum wire wound around a piece of cadmium), it is unaffected by concentrated nitric acid. As soon as the platinum is removed, the cadmium is vigorously attacked. If *dilute* acid is used, the cadmium is attacked regardless of whether the platinum is present or not. To the best of our knowledge, this strange behavior has not yet been satisfactorily explained.

Be that as it may . . . let us proceed. Another important function of nitric acid is as a nitrating agent. To 1 cc. of concentrated nitric acid in a test tube, add a few drops of benzene. Heat gently for a few minutes. Allow to cool; add water and stir. Sniff cautiously at the mouth of the tube. You should be able to detect the odor of almonds. This is nitrobenzene. Nitric acid also reacts with toluene to form trinitrotoluene (T.N.T.) and with glycerine to form nitroglycerine. Both are explosives and are not recommended.

Preparation

Nitric acid can be prepared rather easily in the home laboratory by the action of sulfuric acid on nitrates. However, due to the strong oxidizing power of the vapors, the reaction must be carried out in an all-glass retort. Attach the retort securely to a ringstand with the outlet tube pointed downward. Slip the outlet tube into a large test tube which is immersed in a large container of ice water. Place 5 grams of sodium nitrate in the retort. Using a funnel, carefully add enough concentrated sulfuric acid to completely cover the crystals. Apply gentle heat. Nitric acid vapors will pass over and condense in the cold receiving tube. Collect a small quantity of acid. If the retort should become filled with deep red fumes, all of the acid has been distilled over and the apparatus must be disconnected immediately. The acid obtained is VERY STRONG. Handle it most carefully!

The above method is no longer used to produce nitric acid commercially. It is made from air and ammonia which combine, with the help of a platinum catalyst, to form first nitric oxide and then nitrogen dioxide. The latter is then combined with water to form the acid. It can also be obtained by combining the nitrogen and oxygen of the air with an electric arc and dissolving the resultant nitrogen dioxide in water.

New Chemical Patents

To obtain copies of these new patents, order them by number from the Commissioner of Patents, Washington 25, D. C. Enclose 25 cents in coin, money order or Patent Office Coupons (but not stamps) for each patent ordered.

Solution Buffers Both Hydrogen and Metal Ions

➤ QUITE frequently the control of hydrogen ion concentration and control of metal ion concentration or the simultaneous control of both is necessary for the successful accomplishment of a chemical process.

In many biological reactions metal ions are involved and a study of the system requires that the hydrogen ion and the metal ion be maintained at a constant concentration. It is necessary to buffer the solution both to the hydrogen ion and to the metal ion.

Mr. Frederick C. Bersworth of East Orange, N. J. and Mr. Arthur E. Martell of Northboro, Mass. have been awarded patent No. 2,961,311 for inventing a composition that successfully buffers a solution to both the hydrogen ion and the metal ion. They discovered that compounds having the general formula:

$$\begin{matrix} A & & B \\ > N - \text{Alkylene} - & & N < \\ B & & X \end{matrix}$$

serve to control both of these ions in solution.

Broadly, the invention consists in preparing a solution containing the alkali metal salts of the above chelating agent with metallic chelate of the same compound.

The patent has been assigned to the Dow Chemical Company of Midland, Michigan.

New Process for Cat's-Eye Gem

➤ A METHOD OF making a synthetic gem from ordinary quartz sand has been invented by Mr. John Estell Watson of Cleveland Heights, Ohio. He was given patent No. 2,948,082 for this process.

The process for producing cat's-eye gem involves the passing of molten quartz sand through a die to produce a quartz rod. The quartz rod is drawn with elongated minute rods or pipes parallel to the axis of the rod. The rod is then cut up into portions having a side parallel to the rods or pipes. The portions are ground into the shape of a flat bottom cabochin. The finished gem has an appearance similar to the most expensive natural cat's-eye mineral.

This patent has not been assigned.

Production of Neutrons From Boron — 10

➤ NEUTRON emission upon the excitation of a target element through bombardment with alpha particles is well-known. The use of conventional sources such as radium-beryllium is not very satisfactory for use in radioactive well logging.

A recent patent covers the use of an intimate mixture of boron-10 and either polonium or plutonium. Both

polonium and plutonium are excellent sources of alpha particles. When this mixture is moved along the bore of a well an indication of the carbon content of the formations passed may be obtained by measuring the gamma radiation produced by the neutron bombardment.

Patent No. 2,948,811 has been awarded Mr. Tom W. Bonner of Houston and Mr. Richard L. Caldwell, of Dallas, Texas for this invention. They have assigned the patent to the Socony Mobil Oil Company, Inc. of New York.

Speedy Ion Engine Planned

➤ AN EXPERMINTAL ION engine far different from conventional rocket engines will be built in a year-long $500,000 program sponsored by the National Aeronautics and Space Administration.

As now conceived, the cylindrical ion engine measures only about eight inches long and four inches in diameter but produces an ion stream developing speeds of more than 100,000 miles an hour.

The small laboratory engine will, however, develop only about a hundredth of a pound of thrust. When bigger engines are developed, NASA hopes to use them to propel spacecraft on interplanetary missions.

Their power source would be a nuclear reactor such as the SNAP-8 now being developed.

In the proposed NASA ion engine, an alkali metal atom (cesium) steam passes through an electrode. The hot electrode pulls an electron from the cesium atom, thus creating a positively charged ion that can be accelerated by other electrodes.

Other electrons are mixed with the ion stream so a neutrally charged beam finally leaves the engine.

Hughes Aircraft Company of Culver City, Calif., will design, develop and test the engine under NASA contract.

New Theory for Rusting of Iron

➤ A NEW BASIC explanation for the rusting of iron, one of the most destructive and wasteful chemical reactions known, has been found by scientists at Westinghouse Research Laboratories, Pittsburgh, Pa.

Iron corrosion is believed to waste up to seven billion dollars annually in the U.S. alone. Eighty million dollars alone are spent by automobile owners replacing mufflers each year.

The new theory suggests that hydrogen ions are the culprit. The hydrogen ions come from water vapor, which must be present if iron rusts very much at room temperature. The tiny hydrogen particles are thought to penetrate the iron and enlarge the sites at which oxygen normally combines with the metal.

The previous explanation for iron corrosion was that it is an electrochemical reaction, somewhat like that occurring in an ordinary battery. The new theory suggests that something more fundamental takes place in the iron, although an electrochemical reaction may also be present.

Science Talent Search
Project Report

Thermal Expansion of Liquids

by FRANK A. PODOSEK
Technical High School, Springfield, Mass.

Frank Anthony Podosek, 18, was a winner in the 19th Science Talent Search. He plans to study physics in college in order to become a research physicist.

➤ MY FIRST problem was to devise an apparatus to accurately measure the coefficient of thermal expansion. After many schemes failed or proved impractical, I finally settled on the apparatus shown in figure 1. By weighing the entire apparatus dry and filled with liquid, I found the mass of the liquid being tested. I used a pycnometer bottle to determine the liquid's specific gravity at a particular temperature, and could then calculate the volume of a given mass at that temperature.

As the liquid in the flask was heated, it could expand only up the glass tube. Knowing the height of the liquid in the tube at two temperatures (and thus the height through which it rose in that interval), and knowing the bore of the tube (measured with vernier calipers), I calculated the increase in volume. Carrected for the expansion of the flask itself, the value of this increase, divided by the orginal volume of the liquid, divided again by the number of Centigrade degrees in the temperature interval, gave the coefficient of thermal expansion of that particular liquid.

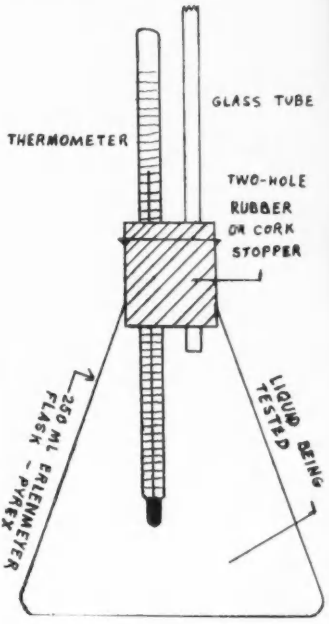
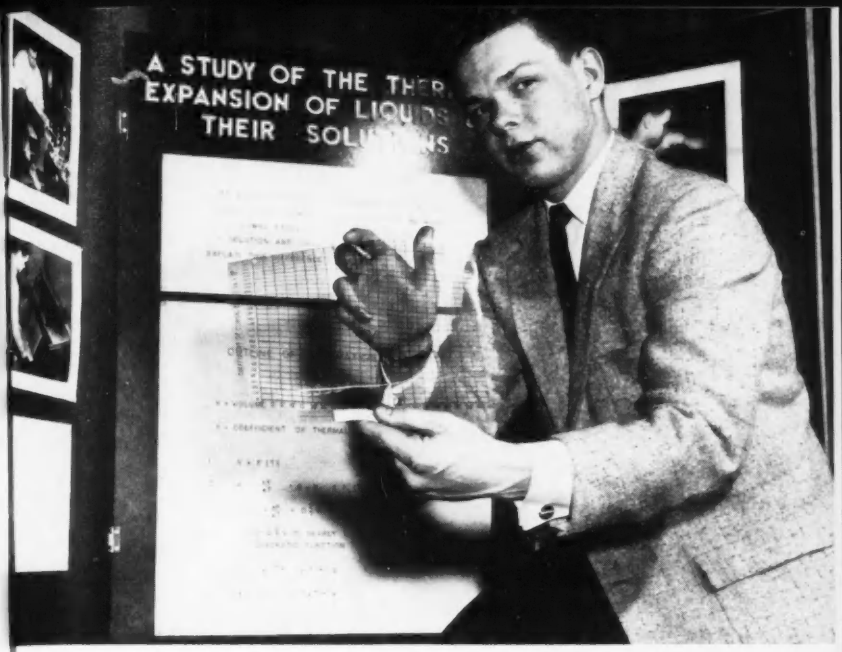


FIGURE 1
Apparatus for Measuring Coefficient of Thermal Expansion

I originally applied heat with a bunsen burner. Results obtained in this manner proved too erratic, and I finally modified my testing apparatus to that shown in figure 2. This makeshift "constant temperature bath" pro-



➤ Frank A. Podosek, *is shown with his science display at an exhibition held in Washington as a part of the nineteenth annual Science Talent Institute. Frank is one of the 40 Science Talent Search winners who were chosen from over 29,000 high school seniors throughout the country.*

vided slow and uniform heating. To further insure uniform temperature change, I heated the liquids being tested past a particular point and made my calculations from data observed as the liquid cooled and contracted.

Included in this report are my experimental coefficients for the substances tested, calculated for each range of five Centigrade degrees. All solvents used were distilled for greater purity. I made all solutions myself. Before sealing it in the flask, I boiled each liquid to drive out all dissolved gases. The values given in this report are derived from a series of tests for each substance.

After collecting and observing my data, I made certain deductions and interpretations, of which I can make but sketchy mention.

At relatively low temperatures water molecules exist in the form of long polymer chains held together by hydrogen bonding. As the temperature rises, these polymers are broken up. Naturally, the constituent molecules collectively occupy a greater volume than they did as a polymer, and

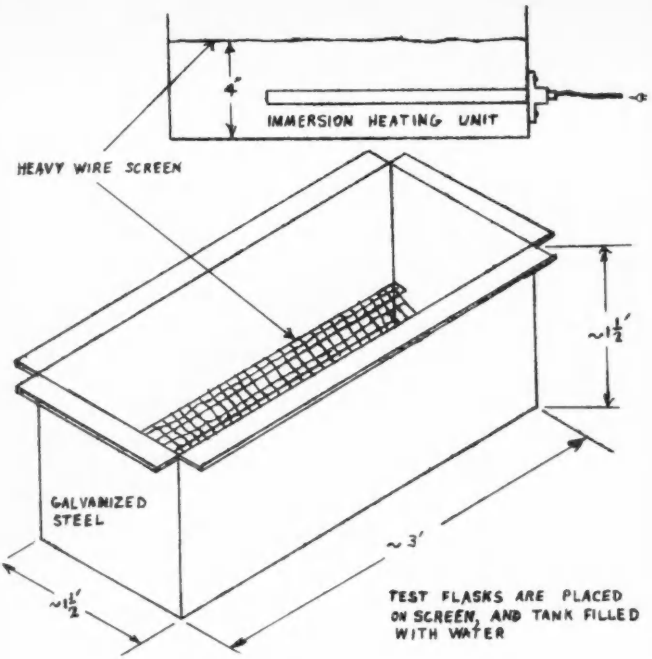


FIGURE 2
Modified Constant Temperature Bath

this raises the coefficient of thermal expansion. This coefficient is further increased with temperature because the degree of ionization of water also increases with temperature, and of course the ions occupy a larger volume than the original molecule.

As can easily be seen, a solute in water has the effect of increasing the coefficient, the increase being greatest at low temperatures. This suggests that a solute tends to break up the water polymers at a lower temperature. The effect is less pronounced at high temperatures because most of the polymers in pure water would be broken up anyway.

Molecular size seems to be a major factor in thermal expansion. The sizes of water, methyl alcohol, and carbon tetrachloride increase in that order. Their coefficients also increase in that order, and in approximately the same proportion. To test the hypothesis

that thermal expansion is roughly proportional to molecular size, I tested a complex organic oil; I found a relatively huge coefficient of thermal expansion.

This hypothesis also explains other observed phenomena. Relatively large molecules such as those of sucrose and cupric sulfate should tend to increase the coefficient of water, and they do. The iodine molecule is quite large, and it exerts a similar effect on CCl_4. In the alcohol-water solution, the average molecular size lies between the sizes of the solvents; the same is true of the respective coefficients.

I was also able to make a semi-mathematical analysis of thermal expansion. Since the volume of a given mass of a given liquid is determined by its temperature, we may consider volume as a function of temperature. That is,

$$V = f(T)$$

The coefficient of thermal expansion is simply the rate of change of volume with respect to temperature. That is,

$$k = \frac{\Delta V}{\Delta T}$$

where k is the coefficient of thermal expansion. Then k is also the derivative of V with respect to T, per unit volume.

$$k = D_T V$$

In studying the graphs, I thought of k as a function of T. Then the derivative of k with respect to T was the second derivative of V.

$$D_T k = D_T^2 V$$

This reasoning led me a step farther. The third derivative of V with respect to T would be the rate of change of the second derivative.

$$D_T k, \text{ or } D_T^2 V$$

would then be equal to $\frac{\Delta K}{\Delta T}$.

The values for ΔK are given in the data, under the column "Second derivative." Although the values in this column are not actually second derivatives, they are in the same proportion as the true second derivatives, and serve better as illustrations. The same holds true for the column "Third derivative."

The fact that the second derivative is very nearly a constant and the third derivative nearly zero enables us to state that $V = f(T)$ is for all practical purposes a quadratic function which can be expressed by the equation

$$V = aT^2 + bT + c$$

In this equation, a, b, and c are constants, c being the volume of unit mass at some reference temperature (e. g. absolute zero), and T being measured from that reference. The values for a, b, and c could easily be calculated for any particular substance, and V at any temperature T could be found using only these values, eliminating the need for long tables of changing coefficients. If k is desired,

$$k = D_T V = aT + b$$

It should be stressed that this is merely an empirical equation. You will notice that for the data $CuSO_4$ in CH_3OH, the derivatives do not obey the usual rules. The function for this substance might be more accurately expressed by a cubic, or even a quartic equation.

Table I

H_2O and CH_3OH

Water and methyl alcohol, 50% volumetric solution

Boiling point: 78° C

Temperature Range in ° C	Coefficient of Thermal Expansion	Second Derivative	Third Derivative
5-10	0.000395		
10-15	425	0.000030	
15-20	448	23	—0.000007
20-25	471	23	0
25-30	495	24	1
30-35	0.000516	21	—3
35-40	536	20	—1
40-45	564	28	8
45-50	593	29	1
50-55	616	23	—6
55-60	0.000636	20	—3
60-65	667	31	11
65-70	699	32	1
70-75	728	29	—3
	Average:	26	0

Table II

$CuSO_4$ in CH_3OH

Cupric sulfate in methyl alcohol

Molarity: 0.45 Boiling point: 70° C

Temperature Range in ° C	Coefficient of Thermal Expansion	Second Derivative	Third Derivative
10-15	0.001160		
15-20	1190	0.000030	
20-25	1219	29	—0.000001
25-30	1261	42	13
30-35	1289	28	—14
35-40	0.001327	38	10
40-45	1372	45	7
45-50	1433	61	16
50-55	1503	70	9
55-60	1585	82	12
60-65	0.001670	85	3
	Average:	51	0.0000055

Insects Chemically Sterilized

➤ CONTROL of house flies and fruit flies by chemical sterilization, so that they cannot reproduce, is being tried in experiments by the U. S. Department of Agriculture.

The experiments, involving one of three new methods of insect control proposed by USDA's Dr. Edward F. Knipling, make use of a modified glutamic acid to bring about self-annihilation of insects by chemical sterilization.

Tests have shown that a concentration of as little as one one-hundredth of one percent of this chemical, added to food for laboratory-reared house flies, has prevented egg-laying or hatching and that one-half of one percent in a single feeding will cause permanent sterility in female flies.

Male flies, according to tests made so far, are not sterilized by eating food containing the chemical. To be fully effective, chemical sexual sterilants of maximum effectiveness will have to produce sexual sterility in both males and females without adverse effects on mating behavior.

Chemical sterilization, if eventually successful, would not require release of treated flies to wipe out normal ones because food treated with an effective chemo-sterilant could be made generally available.

Although satisfactory for use in testing the principle of chemical sterilization, the USDA points out, modified glutamic acid may not prove completely suitable as a practical means of insect control by this method.

The other two control and eradication methods suggested by Dr. Knipling include the production and release of diseased insects to infect and kill their own kind, and of insects possessing lethal genetic traits that could control an insect pest.

New Uses for Uranium

➤ THE USE OF depleted uranium in the steel industry, in the construction of shielding materials and in various alloys, has been suggested by metallurgists at the Battelle Memorial Institute, Columbus, Ohio.

According to Vincent Barth and George Rengstorff in the July edition of the Battelle Technical Review, stocks of depleted uranium, from which the fissionable isotope U-235 has been extracted, are accumulating at a rate of "tens of millions of pounds a year."

The metallurgists point out that uranium is still too expensive to compete with metals now in use in the steel and alloy industries, but think that the price might be lowered if increased demand were to lead to better methods of preparation.

The uses suggested for the metal include its alloying in tool steels, bearing metals, and high density alloys. It might also be employed as a scavenger for impurities in steels and other metals, and as a spheroidizing agent in making nodular iron.

A New Journal

➤ In January 1961 the ACS will start publication of the new JOURNAL OF CHEMICAL DOCUMENTATION to answer a growing need for an exchange of information on all aspects of communication in the chemical field. The new journal will be edited by Dr. Herman Skolnik, Manager of the Technical Information Division of Hercules Powder Company. The papers it publishes will bring together the leading minds and top training in the field.

It will be issued twice a year and will publish some 25 or more papers per issue. Here is a partial list of some of the articles to look for next year:

"Data Interchange During the International Geophysical Year"

"Abbreviations in Russian Chemical Literature"

"The Technical Editor in Industry"

"French Organic Nomenclature"

"Technical Translating"

"New Kinds of Indexes"

"Editing Organic Abstracts for CHEMICAL ABSTRACTS"

"The Present Status of Forensic Chemistry"

"Detecting Corresponding Patents from Different Countries"

"Legislation and Regulations Relating to Air, Vegetation and Stream Pollution"

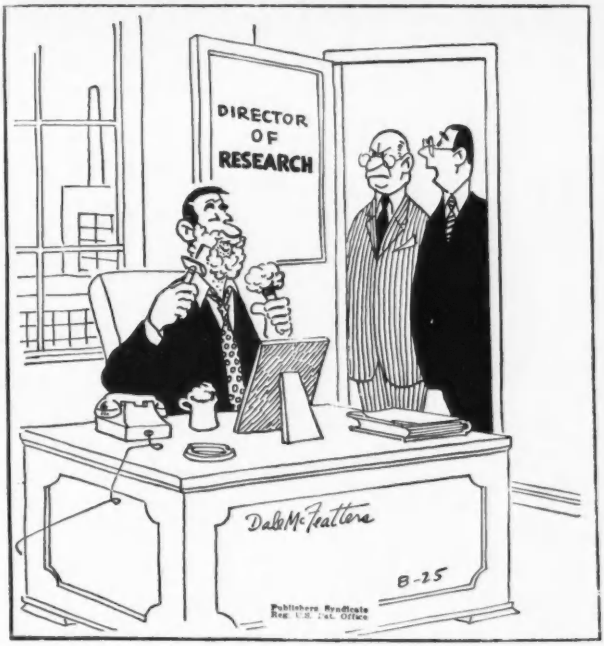
"Nomenclature of Carbohydrates"

Documentation is concerned with every phase of a document from idea conception to production, through publication, need and selection of the document by a user, reading and retrieval of information, its reworking and correlating to the user's needs and purposes. Documentation takes an increasing number of forms today and uses a growing variety of techniques.

It covers such areas as: classification, searching, organization and dissemination of information, new tools and equipment, new techniques, the use of mechanical and electronic machines for documentation, and systems for using these machines.

Since the subject of documentation will continue to grow, the scope of JOURNAL OF CHEMICAL DOCUMENTATION will keep broadening. The field is alive with new developments. More and more companies are setting up technical information centers. More libraries are expanding their services. More disciplines are interested in the field of information: not only chemists and allied scientists but also linguists, writers, publishers, systems experts and librarians, machine designers, and printers. Documentation takes in science, logic and semantics, printing, duplicating, microreproduction, transmission and distribution, foreign languages, and library science.

A recent estimate has been made that the amount of chemical literature which will be published in the next three years will be equal to, or greater than, all the chemical literature that has been published so far. This is proof that the JOURNAL OF CHEMICAL DOCUMENTATION comes on the scene at a highly opportune time.



"But he says he gets his best ideas while shaving!"

Stretch Paper Promises Throw-Away Clothes

➤ A NEW KIND of paper that stretches in all directions is being boosted for use as disposable bedsheets, diapers, draperies, slipcovers, sterile medical gowns, nurses' and barbers' uniforms, and similar products.

The all-way stretch paper developed from research work with a commercially sold paper that stretches lengthwise. The new paper is now "halfway between pilot production and actual commercial manufacture," reports Gerald E. Amerman, president of Clupak, Inc., the firm holding the stretch-paper patent.

Mr. Amerman said experiments indicate that even a practical leather substitute might be developed using a combination of extensible heavyweight paper and resins.

Production of the older paper involves pressing together the fibers in a wet sheet of paper between a rubber blanket and a heated, polished cylinder. The new paper is made by controlling the recoil of the rubber blanket so the paper sheet is compressed in all directions, not just lengthwise.

Silica Gel Anniversary

➤ THIS YEAR is the 40th anniversary of the first commercial production of silica gel, one of the most versatile and widely used of the products synthesized through modern chemistry.

First employed in significant quantities as a desiccant, to take on moisture, oil, or other materials, many other applications have been researched and found practical. But it is as a desiccant that some of the most interesting developments with silica gel have been registered in the 40th year of its use.

Radar equipment, rocket motors, the delicate mechanisms of space vehicles and their ground support devices have all been protected from moisture damage by silica gel, and in at least one instance a quantity of the chemical was lofted miles into space.

This upward flight was countered by a trip to the lowest depths of the ocean, when the Navy's Trieste bathyscaph made its record dive. To maintain protection of the instruments 40 bags of silica gel were stowed in the sphere. When the dive started, relative humidity was 85 per cent in the outside air, 12 per cent inside the sphere.

It is as a desiccant also that silica gel has recently revealed an entirely new type of effectiveness — as an insecticide. Known as "Dri-Die" this new product in pest control acts on insects by attacking the waxy or oily layer of skin. When the cuticle is penetrated by the action of the silica gel, the insect rapidly loses body fluids to the atmosphere, and it dies by dehydration.

The significance of this action, according to entomologists, is that it is basically physical rather than chemical. Insects, accordingly, may not develop the resistant strains which have rendered ineffective many of the commonly used chemical insecticides.

Research on silica gel as an insecticide was done first by the University of California at Los Angeles; later work at Grace's Washington Research Center. It is typical of the research by public and private laboratories which, over the years has developed so many applications for the many-sided chemical, silica gel, and continues to open new avenues of utility.

By such means, an annual volume for silica gel of about 275,000,000 pounds has been built up, with a value at the manufacturer's level of about $50,000,000.

The Product

It is essentially silicon dioxide (SiO_2) and hence is chemically very similar to ordinary sand. In physical properties it is entirely different. It is non-crystalline (amorphous) rather than crystalline in structure; it is porous, which sand is not; it is light rather than heavy. In manufacture, these properties are subject to wide but controlled variation. Literally, it can be produced with almost unlimited variations in qualities, enabling it to be tailor-made for a specific use. These uses run into the hundreds, and are constantly being expanded. As its basic characteristics change, the

product varies in appearance, ranging from light colored granules to a very fine white powder.

There are two broad areas of application of silica gel — its use in adsorption and its use as a base for catalysts, notably those employed for petroleum cracking. About 275,000,000 lbs. a year, valued at about $50,000,000 at the manufacturer's level, is produced in the United States.

History

Silica gel was once a laboratory curiosity, of no commercial importance, because a practical method of manufacturing it had not been developed. Dr. Walter A. Patrick, a professor of physical chemistry at The Johns Hopkins University, made an essential contribution when during World War I he was asked by the U. S. Chemical Warfare Service to develop a material for adsorbing vapors and gases in gas mask canisters.

It was in 1920 that manufacture of silica gel was started by a company since acquired by what is now W. R. Grace & Co.'s Davison Chemical Division. But although it was widely touted as a new "wonder chemical", little actual market development took place until the '30s, when Davison undertook an intensive program of research and promotion. The first use to become commercially established was as a desiccant (moisture adsorber or drying agent) in refrigeration work. Later, desiccant uses expanded enormously in World War II and coincidentally there was established the petroleum cracking catalyst use, in response to the tremendous demands of the armed forces for high quality anti-knock gasoline and other petroleum products.

Davison, the largest producer, makes virtually all currently used forms of silica gel and is also the largest producer of gel cracking catalysts. (The first plant for commercial production of such catalysts was built by Davison at Curtis Bay, Baltimore, in 1942).

Manufacture

Simple ingredients are the bases of silica gel manufacture — sulfuric acid and sodium silicate, or water glass, once used by farm families for preserving eggs. Sodium silicate is made from sand and soda ash.

The manufacturing process is deceptively simple. The two basic ingredients are mixed and they set to a jelly-like mass called hydrogel — whence the name of the product. The hydrogel is broken up and washed to remove acid and salts resulting from the reaction. It is then dried, crushed and screened to the desired size, after which it is given a final drying or activation.

Simple outwardly but among the qualities subject to close control in manufacture are particle size, porosity, density, and acidity. It can also be pelleted or given other definite physical forms.

Structure

Although silica gel is in the form of hard granules, it has an extremely porous structure. The presence of millions of tiny tunnels, too small to be seen by any microscope, is inferred from the qualities of the material. These give an enormous surface area — in a typical product, 90,000 sq. ft. to 1 cu. in. of gel, or the same surface area as two football fields.

This relatively huge surface area gives silica gel its phenomenal capacity for taking on water vapor or other substances by surface adsorption and capillary attraction. (Note it is "adsorption", implying that the substance adheres to the surface of the gel — "surface" including the surface areas of the pores or tunnels — rather than "absorption".)

Also, in catalytic applications, the surface area is important as giving maximum contact between the catalyst and the substance being reacted.

An amazing quality of silica gel, in many of its most used forms, and especially as a petroleum cracking catalyst, is that when produced as a very fine powder, it can be made to act as a liquid.

Toss it in a tumbler, and it seems to slosh around like water. This quality enables its use in fluid processes in the refinery — the oil companies have a simple demonstration which shows celluloid ducks apparently swimming around in waves of water — actually the gel catalyst under aeration.

Another astonishing quality is that when the gel is used as a desiccant, it can take on up to 40 per cent of its weight in water vapor — be soaking wet in fact — and show no signs of it whatever — continue to look and to feel as dry as dust.

Berkeley Bevatron Improvements

➤ An extensive program of improvements to the 6.2 billion-electron-volt bevatron are planned by the University of California's Lawrence Radiation Laboratory.

The scheduled modifications will permit a greater number and wider range of high-energy experiments with the giant proton accelerator. They will improve the machine's efficiency and usefulness in nuclear research.

The improvements, expected to begin shortly and to be essentially complete by the spring of 1964, will cost about $9.6 million. Funds are being provided by the U. S. Atomic Energy Commission.

The bevatron has pioneered a new phase of nuclear research, making possible the discovery of the antiproton, the antineutron and other particles.

The changes will not increase the energy of the protron accelerator, but more protons will be accelerated. Ten bursts of protons are now fired each minute by the pulsed machine, with about 100 billion protons in each burst. After the modifications, it is hoped that some 10,000 billion protons will emerge in each burst.

The new program calls for a completely new injection system, consisting of a new ion gun and a new linear accelerator that will fire protons into the bevatron at an energy of about 20 million electron volts.

A second major facility to be added will be an external proton beam which can strike a target outside the machine, making some types of experiment easier to carry out, including the detection of particles with extremely short half-lives.

Experiments With Radioisotopes

➤ The Atomic Energy Commission has published the first full-fledged laboratory manual on radioisotopes for use in college and university chemistry courses.

The manual, titled "Radioisotope Experiments for the Chemistry Curriculum," (TID 6374) was prepared, under contract, for the Commission's Office of Isotopes Development. It is designed to introduce the chemistry student to radioisotope techniques and to demonstrate their potential contribution to his future work. Preparation of the manual reflects the growing routine use of radioisotopes as a valuable tool in chemistry and biology laboratories, hospitals and many scientific research centers.

Faculty members of Northwestern University, Illinois Institute of Technology, and Pennsylvania State University have participated in developing the experiments. Testing of the experiments was carried out under actual teaching circumstances at Penn State, Emory University, Loyola University (Chicago), St. Procopius College, Monmouth College and Illinois Wesleyan University. Editorial supervision and administration of the project was provided by the Nuclear-Chicago Corporation under a cost-sharing contract.

The experiments have been developed and tested for a maximum laboratory group of thirty students. Since many academic institutions find it difficult to set up an entirely new course in already crowded schedules, most of the experiments may be easily worked into established courses.

Ten introductory experiments illustrate the properties of radioisotopes, radiation and the instruments involved in their detection. Twenty-three other experiments illustrate important chemical facts and relationships that have well-established roles in the teaching of chemistry.

All of the experiments may be done without special AEC license, with a package of radiocompounds stock-ordered from licensed suppliers. Only basic nuclear detection equipment already available at reasonable costs from any commercial supplier is necessary to conduct any of the experiments.

A sample copy of the manual, together with a set of instructor notes, is available to colleges and universities upon request to the Director, Office of Isotopes Development, U. S. Atomic Energy Commission, Washington 25, D. C.

Multiple copies for student use may be purchased through the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., at $2 per copy for the experiment manual and $1 for the instructor notes.

The Atomic Energy Commission has, in the past, sponsored publication of two laboratory handbooks for secondary school science instruction. These are: "Laboratory Experiments with Radioisotopes for High School Science Demonstrations" and "Teaching with Radioisotopes."

Sequence of Amino Acids Unraveled

➤ SCIENTISTS at the University of California's famed Virus Laboratory have scored again, this time by determining the exact sequence in which amino acid units are chained together to form a protein molecule.

Their "guinea pig" was the tobacco mosaic virus, a living, rod-shaped particle about a hundred-thousandth of an inch long.

The virus consists of two major parts: a core of nucleic acid and an overcoat of protein. The protein overcoat is composed of about 2,200 identical protein molecules, each of which contains a single chain of 158 amino acid units.

Six months ago two members of the Berkeley team, Dr. Akira Tsugita and Dr. Heinz L. Fraenkel-Conrat, reported that detectable change had occurred in the amino acid unit third from the bottom in the 158-link protein chain. The change was a result of a chemically caused mutation, or heredity alteration.

Pinpointing of this change provided a landmark in the long chain and allowed the researchers to determine what chemical unit followed the landmark and what unit preceded it, until the entire sequence was known.

The discovery marks the first complete analysis of the amino acid sequence in a virus protein, the largest protein of any kind and the largest genetically governed molecule ever analyzed.

Sharing in the discovery, reported in the Proceedings of the National Academy of Sciences, were Nobelist Dr. Wendell M. Stanley, Drs. Janis D. Young and C. Arthur Knight, and Dr. Duane T. Gish, now of Upjohn Research Laboratory, Kalamazoo, Mich.

Concentrated Fertilizer

➤ A NEW FERTILIZER more concentrated than any currently marketed has been developed by chemical engineers of the Tennessee Valley Authority.

The product contains about 77% plant food, according to J. G. Getsinger, TVA chemical research supervisor. The granular ammonium polyphosphate offers economies in handling, shipping, and storage, he said.

Besides standard fertilizer uses such as direct application to soil and blending with other fertilizer materials, this product should be useful to liquid fertilizer manufacturers in preparing highly concentrated solutions. A 10% increase in plant food is now possible over the regular electric furnace phosphoric acid method of making liquid fertilizer.

The process for producing the granular ammonium polyphosphate involves feeding ammonia and superphosphoric acid to a reactor operated under moderate pressure and temperature. Under these conditions, the product is a melt that flows freely. After discharge from the reactor, the melt is mixed with other process ingredients to produce a granular product.

"Transfusion" from Strawberry

▶ STRAWBERRY plants can transmit a growth-promoting hormone to pea plants by way of temporary grafts, Dr. P. A. Thompson of the Scottish Horticulture Research Institute, Dundee, has found.

To achieve the chemical transfusion, he grafted the top part of embryo pea seedlings to the leafstalks of mature strawberry plants.

In strawberry plants growing under long-day conditions, a substance believed to be a hormone steps up vegetative growth and inhibits flowering. Gibberellic acid will produce the same effect, when sprayed on pea plants growing under short-day conditions, and will boost the strawberry's growth even further when sprayed on that plant.

To determine whether the strawberry hormone as well as gibberellic acid could stimulate growth in pea plants, Dr. Thompson grafted the young peas to the strawberries. The two different tissues did not grow together, but there was a transfer of growth hormone from strawberry to pea.

The amount of increased growth in the grafted peas was equivalent to that produced by applying one-fiftieth of a microgram of gibberellic acid to untreated pea plants.

Spraying the strawberry hosts with gibberellic acid caused grafted peas even greater growth.

Dr. Thompson also reported in Nature that if the strawberry plants were chilled before grafting, the peas grew better than when grafted to unchilled hosts. This is probably because winter chilling of strawberries acts as a "dormancy breaker" that results in a growth spurt when the plant is in favorable growing conditions.

Science Career Planning

▶ TO BECOME a space scientist or a weather expert, take all the high school science you can get, plus lots of college chemistry or physics or both.

This advice comes from the Bureau of Labor Statistics and the U. S. Office of Education in a free pamphlet for students, "Science and Your Career."

Science careers requiring various amounts and kinds of high school, vocational school, college or postgraduate training are listed in this pamphlet, which is designed to encourage students to make informed and adequate plans for their education and future careers. Specific reference is made in each case to detailed information presented in the U. S. Department of Labor's "Occupational Outlook Handbook" and in reprints covering each career specialty.

Reprint leaflets on such fields as architecture, chemistry, dietetics, sheet metal work, physics, printing, teaching, etc., are available at prices ranging from five to twenty cents a copy from the Superintendent of Documents, Washington 25, D. C. The 1959 Handbook also may be purchased at $4.25 a copy.

Book Condensations

Cosmetic Science — A. W. Middleton, Ed. — *Butterworths, (Canada)*, 327 p., illus., $12. Papers and discussions of the First British Congress on Cosmetis Science, London, 1959.

Structure and Change: An Introduction to the Science of Matter — G. S. Christiansen and Paul H. Garrett — *Freaman*, 608 p., illus. by E. L. Gillespie, $8.75. Introduces the student to the scientific view of the physical world, concentrating on the structure of matter.

An Introduction to Chemical Nomenclature — R. S. Cahn — *Butterworths, (Canada)*, 96 p., paper, $2.25. Describes principles of modern systematic nomenclature and treats both inorganic and organic chemistry.

Crystal Growth: Discussions of the Faraday Society, 1949 — N. F. Nott and others, introd. by W. E. Garner — *Butterworths (Canada)*, 366 p., illus., $12. Papers and discussion of nucleation and normal crystal growth, abnormal and modified growth, and technical aspects of mineral synthesis.

A Statistical Manual for Chemists — Edward L. Bauer — *Academic*, 156 p., $4.75. For chemists who perform experiments, make measurements, and interpret data.

Molecules In Motion — T. O. Cowling — *Harper* 183 p., paper, $1.35. An introduction to the kinetic theory of gases.

X-ray Powder Photography: In Inorganic Chemistry — R. W. M. D'Eye and E. Wait — *Academic*, 222 p., illus., $8.50. Written primarily for the research chemist with no experience of crystallography, giving the necessary background for understanding the powder method of observing X-ray diffraction in the laboratory.

Molecules in Motion — T. O. Cowling — *Harper*, 183 p., paper, $1.35. An introduction to the kinetic theory of gases.

Ultraviolet Guide to Minerals — Sterling Gleason — *Van Nostrand*, 244 p., illus. in color, $6.95. A working manual for the use of ultraviolet light in locating and recognizing minerals, includes field identification charts.

Introduction to Textiles — Evelyn E. Stout — *Wiley*, 363 p., illus., $6.50. Describes some ninety natural, thermoplastic and non-thermoplastic man-made fibers, discusses wash-and-wear developments and modern texturizing processes.

Chemical Technology of Petroleum — William A. Gruse and Donald R. Stevens — *McGraw*, 3rd ed., 675 p., $15. Covers the chemistry of petroleum and modern methods, standards and practices of petroleum distillation and refining.

An Introduction to Practical Infra-red Spectroscopy — A. D. Cross — *Butterworths (Canada)*, 80 p., paper, $3.50. Standard reference data.

Chemistry Comments

Interesting facts in the chemical world.

➤ Without the aid of a catalyst, it is estimated that pressures of 3,000,000 pounds per square inch and temperatures of over 7,000 degrees Fahrenheit would be required to transform carbon into synthetic diamond.

➤ Development of a marketable pesticide takes from four to eight years and costs from $500,000 to $1,000,000.

➤ Synthetic diamonds are made by placing carbon and a catalyst metal in a pressure cell and subjecting them simultaneously to pressures ranging from 800,000 to 1,800,000 pounds per square inch and temperatures from 2,200 to 4,400 degrees Fahrenheit.

➤ Alumina, the white oxide from which aluminum is smelted, is used in the fabrication of nose cones for the Sparrow III guided missile.

➤ Fast nuclear reactors can be designed to create more fuel than they consume, and for this reason such a reactor is termed a "fast breeder."

➤ Narcoanalysis is the technique of employing drugs such as sodium amytal to stimulate the patient's talk.

➤ Ether was discovered in the 16th century by Valerius Cordus, who synthesized it from sulfuric acid and alcohol but did not know of its anesthetic powers.

➤ At temperatures within a few degrees of absolute zero, many metals become superconductors in which state the electrical resistivity vanishes completely.

➤ The tensile strength of ice can be tripled by adding 15% sawdust.

➤ A six-ounce sweet potato contains more than twice the amount of vitamin A needed daily by the human body, and the value increases during curing and storage.

➤ Lignite, an intermediate product in the formation of soft coal, is a new source of low-cost chemicals that soften rubber and protect it from oxygen attack.

➤ Military usage of aluminum dates back to 1854 when Emperor Napoleon III ordered lightweight aluminum armor and other equipment for his troops.

➤ The X-ray was discovered in 1895 by Wilhelm Conrad Roentgen, a German physics professor, while he was running an electric charge through a vacuum tube.

➤ Of all the men who have ever been trained in science and technology, it is estimated that 90% of them are alive today.

➤ Tung oil, once used in the famous lacquers of ancient China, is a superior drying oil for paints.

➤ A study has recently been completed further establishing the existence of a chemical basis for behavior, and showing that the environment can apparently change the brain chemistry.

➤ Pharmaceutical research costs the U.S. drug industry $200,000,000 yearly.

XUM